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State of Montana

Proposal

for

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

VOLUME THREE:
UNIVERSITY AND VENDOR SUPPORT APPENDIX

March 1, 1991

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MSU Physics Department

The department of physics plays a major role in MSU's three-fold mission of teaching, research and service. As a provider of instruction in the most fundamental physical science, the department serves undergraduate physics majors and graduate students as well as undergraduates majoring in engineering, architecture, agriculture, education and the sciences. It contributes to the core curriculum, offering a wide range of courses in physics and natural science and a course in technology. Research programs within the department are focused in a few well-defined areas: laser spectroscopy and nonlinear optics, relativity and astrophysics, critical phenomena, surface science, physics teaching and electrical discharges. Every faculty member is expected to maintain a productive program of research or other creative activity. In the following paragraphs, faculty research interests are briefly outlined. The descriptions give special emphasis to the two groups, relativity and laser optics, whose interests most closely parallel those of future LIGO staff and scientists; curriculum vitae for faculty in the latter groups are appended.

Faculty Research

Three faculty conduct research in gravitation, relativity and cosmology. **William Hiscock** (Associate Professor, Ph.D., Maryland, 1979) studies relativistic astrophysics, the quantum theory of gravity, and relativistic fluid dynamics. He is investigating the evolution of charged black holes as they evaporate, gravitational particle production in the early universe, and the gravitational effects of such objects as magnetic monopoles and strings. **Lee Lindblom** (Associate Professor, Ph.D., Maryland, 1978) has interests at the interface between mathematical gravitation theory and astrophysics. Recent work has included the investigation of the gravitational radiation driven instabilities that limit the rotation rate of neutron stars and the study of theories of dissipative relativistic hydrodynamics. **Kenneth Nordtvedt** (Professor Emeritus, Ph.D., Stanford, 1964) is studying several problems in theoretical physics, including calculations in relativistic gravity, solar sytem orbital phenomena, and cosmological effects.

Professor **Sachiko Tsuruta** (Ph.D., Columbia, 1964) is involved in several theoretical problems of high energy, plasma, relativistic and nuclear astrophysics, with emphasis on dense matter in neutron stars and ultrahot plasmas around supermassive black holes. Current research includes calculations of neutron star cooling and the effects of superfluid particles, pion condensates, and strong magnetic fields; and construction of viable models of a central power source in active galactic nuclei.

Laser optics and spectroscopy are interests pursued by two faculty in our department. **John Carlsten** (Professor, Ph.D., Harvard, 1974)

is involved in the study of the interaction of intense laser fields with atomic and molecular vapors and gases. Nonlinear optical interactions such as stimulated Raman scattering (SRS) and 4-wave mixing are also studied, as well as transiency in SRS and the resulting formation of solitons in the pump depletion regime. He is also investigating the role of spatial coherence in SRS. **Rufus Cone** (Professor, Ph.D., Yale, 1971) carries out optical hole burning, nonlinear frequency mixing spetroscopy, resonance excitation of fluorescence, and laser Raman spectroscopy in studies of condensed matter and molecular processes.

Theoretical research in condensed matter physics and surface science is carried out by **Adolfo Eguiluz** (Associate Professor, Ph.D., Brown, 1976) and **John Hermanson** (Professor and Acting Head, Ph.D., Chicago, 1966). Problems addressed include surface phonons, surface electronic structure including collective excitations, chemisorption and surface magnetism. Theoretical studies of phase transitions and critical phenomena in solids and polymers are conducted by **George Tuthill** (Associate Professor, Ph.D., M.I.T., 1975). Professor **Richard Robiscoe** (Ph.D., Chicago, 1964) publishes theoretical work on the propagation of electromagnetic pulses.

Condensed matter and surface science experimental studies are performed by Professors **John Drumheller** (Ph.D., Colorado, 1962), **Gerald Lapeyre** (Ph.D., Missouri, 1962), **Hugo Schmidt** (Ph.D., Washington, 1961), and **Richard Smith** (Ph.D., Iowa State, 1975). Areas studied include surface vibrations using high resolution electron energy loss spectroscopy, surface electronic structure based on angle resolve photoemission spectroscopy, ion beam scattering on solid surfaces and interfaces, electron paramagnetic resonance and magnetic susceptibility, nuclear magnetic resonance and optical scattering studies of critical phenomena.

The department also has an active group effort in science education, developing and implementing innovative programs for primary and secondary teacher education, developing techniques in education for non-science majors, and bringing science understanding to the public. Two faculty focus their research in these areas: **Larry Kirkpatrick** (Professor, Ph.D., M.I.T., 1968) and **Gerald Wheeler** (Professor, Ph.D., stony Brook, 1972).

Graduate Program

Both M.S. (thesis and non-thesis options) and Ph.D. degrees are awarded by the department of physics. In the ten-year period 1981 t0 1990, autumn quarter registration in physics graduate degree programs has increased from 30 to 62 students; thesis registrations increased from 14 to 24 over this period. Almost all graduate students are supported through teaching and research assistantships, and graduate fellowships. A comprehensive list of courses including both core and specialized topics is offered by the department; these include, for example, a three-quarter sequence of advanced courses in general relativity and a two-quarter sequence in atomic physics and quantum optics.

Research Facilities

Laser laboratories include a Lambda-Physik excimer laser (oscillator-amplifier design) that produces 20 MW pulses 15 ns in duration, a Molectron YAG laser with 50 MW pulses that can run in single axial mode or single transverse mode, a Quantum Ray YAG laser running with an unstable resonator design, two pulsed nitrogen lasers and three pulsed narrow-bandwidth tunable organic dye lasers which can be scanned by computer-controlled stepper motors. A 60 kilogauss superconducting solenoid magnet and high resolution spectrometers allow nonlinear mixing spectroscopy, two photon absorption, coherent optical transient spetroscopy, resonance fluorescence spectroscopy and laser Raman spectroscopy to be carried out on a variety of solid state and molecular sytems. Stimulated Raman scattering, soliton formation and 4-wave mixing interactions are studied using nonlinear interactions of intense optical fields with gases and vapors. See the appended list, "Major Laser Equipment" for additional details.

Our Center for Research in Surface Science is dedicated to a number of surface and interface spectroscopies, including high resolution scanning Auger, X-ray and ultraviolet photoemission, high resolution electron energy loss and secondary ion mass spectroscopies. A molecular beam epitaxy machine has made possible the fabrication of metal-semiconductor interfaces at the level of single atomic layers. The department houses a scanning tunneling microscope with energy dispersive X-ray analysis, a 2-MeV Van de Graaf ion beam facility for Rutherford backscattering, and a video LEED apparatus with computer-controlled spot intensity profile measurement capability for analyzing the atomic geometry of surfaces and interfaces.

A separate solid state laboratory provides facilities for the study of the magnetic and electric properties of materials. Particular attention is focused on phase transitions and critical phenomena in magnetic and ferroelectric systems. The laboratory includes 9-inch and 15-inch Varian electromagnets, modern electron paramagnetic resonance and nuclear magnetic resonance spectometers, a high pressure facility with a diamond anvil cell, and a laser for Brillouin and Raman scattering experiments. Electrically active polymers are currently under study.

Other Facilities

A comprehensive collection of scientific journals, textbooks and reference materials necessary for the research programs in the physics department is located in a modern, well-kept library. In addition, the department has its own reading room in which selected physics journals and reference materials are available. Well-equipped electronic and machine shops supervised by competent technicians are also available for use.

To support research, MSU maintains several VAX 8550 mainframes as

well as a number of distributed MicroVAX minicomputer systems. Math libraries and graphics packages are available to users of these systems. Campus computing resources are linked on Ethernet; PCSA software provides a means for integrating personal computing into the multiuser computing environment. PC's and workstations are found in research laboratories and offices; many are connected to the campus network. The Office of Systems and Computing Services provides excellent user assistance. Connection to NSFNET is provided via NorthwestNET, allowing an efficient access to remote Supercomputer Centers.

Physics Department Commitment to the LIGO Siting Bid

The department of physics is strongly attracted by the striking opportunities provided by the LIGO project. The existence at MSU of a leading relativity group with interests in gravitation theory and, especially, the sources of gravitational waves, would provide both stimulus and support for the LIGO experimenters. Scientists visiting the observatory would be able to confer with theorists at MSU interested and qualified in gravitation theory. The local group could assist visitors in obtaining access to the necessary journals and computational facilities. The physics department could provide temporary office space and secretarial assistance for those visitors who wished to spend a few days or perhaps a sabbatical leave at MSU. The relativity group and indeed the entire physics department would form an eager and supportive audience for visiting LIGO scientists.

To capitalize on the opportunies afforded by the observatory, should it be located in Montana, and to offer the strongest possible suport to its activities, MSU has requested that the state legislature fund the addition of two new tenure track faculty positions in the physics department. The first faculty position, in relativity, would be in an area of gravitation theory associated with the study of the sources of gravitational waves; these include neutron stars, black holes, supernovae, close binary systems and other more speculative sources such as cosmic strings and primordial cosmological waves. The new faculty member could collaborate effectively with the present relativity group; Hiscock and Lindblom have both published work on sources of gravitational waves.

Laser optics research is another important emphasis of the physics department. The activities of a new faculty member in this area would act as stimulant for interactions with the optical development projects of the observatory. Thus, MSU has requested that the legislature fund a second faculty position in support of the LIGO siting bid, a position in thecretical nonlinear optics and quantum optics. The proposed position would include research areas such as multiwave mixing, coherent transients, photon statistics and quantum noise and its reduction. This position would be a strong addition to the ongoing research at MSU, but it would also be in a field where a totally independent research program would be possible.

Should the legislature be unable to commit the funds in support of the requested faculty positions in relativity and optical theory, the physics department would establish a postdoctoral research position in gravitation theory, supported by departmental and university funds for a minimum of four years, assuming the observatory is sited in Montana. Faculty in the relativity group and the physics department head would be responsible for conducting a search for candidates to fill the position. An important selection criterion would be the candidate's potential for carrying out a successful program of research on the sources of gravitational waves.

The physics department's long-range plan includes the addition of a third tenure track faculty member in the relativity group near the middle of the decade. This action, presumably made possible by one of several anticipated retirements, is not dependent on the success of the LIGO siting bid. As noted above, the department has a long-standing commitment to excellence in relativity theory. Our nationally recognized leadership in this area of research would be further strengthened by close ties with the new observatory.

Capabilities

1. Studies of Raman generators where the growth is from spontaneous Raman scattering. Determination of the angular spectrum of emitted radiation with the use of linear photodiode arrays. Determination of the role of 4-wave mixing in the generation of anti-Stokes emission and other higher-order processes.

2. Studies in transient stimulated Raman scattering. Utilizing fast storage oscilloscopes, the role of coherent decay on the transiency can be determined.

3. Studies of the use of multiple-pass cells in the enhancement of non-linear interactions.

4. Generation of soliton pulses in stimulated Raman scattering.

5. Studies of the influence of spatial inhomogenities of the laser beam on the phase fidelity of Raman amplification.

6. Study of the role of 4-wave mixing and phase matching in non-linear interactions in gas phase media.

Major Equipment

1. Lamba Physik eximer laser (model EMG-150ET). This laser has an oscillator-amplifier design and produces 300 mJ, 15 nanosecond, 20 MW pulses at 25 pps. The laser can run on ArF, KrF, XeCl or XeF with wavelengths of 193 nm, 248 nm, 308 nm or 350 nm. The bandwidth of the laser is typically 1 cm^{-1} wide and the spatial beam quality is ~ 2 x diffraction limited.

2. Molectron MY-34 YAG laser. This laser produces 750 mJ, 15 nanosecond, 50 MW pulses at 10 pps. The fundamental wavelength is 1.06μ but non-linear crystals are available to obtain 0.53μ and 0.35μ. The laser can run single axial mode and single transverse mode.

3. Six 4'x8'x8'' optical tables (Newport Research Corporation Model RS).

4. Storage oscilloscope (Tektronix model 7834). Single beam, dual trace, 400 MHz capability.

5. Quantum Ray DCR-3 YAG laser. This laser produces 850 mJ, 9 nano second pulses at 10 pps. The fundamental wavelength is 1.06 n but a non-linear crystal is available to obtain 0.53 n. The laser runs with an unstable resonator design.

LASER SPECTROSCOPY LAB - RUFUS CONE

Capabilities

A variety of advanced and conventional spectroscopic methods are applied to studies of condensed matter:

1. Photon echo studies of relaxation and energy transfer (diffusion) phenomena in excited states with pulsed lasers - electronic delay for two tunable dye lasers, stable and controllable to 1 nsec by computer. Pockels cell shutter. Entire visible spectrum.
2. Phase-switched optical coherent transients with time resolution to <500 picoseconds (optical analog of pulsed nmr), plus frequency-switched coherent transients using actively-stabilized single freqnency cw dye laser (Ar^+ laser - pumped) and appropriate acousto-optic and electro-optic modulators.
3. Spectral hole burning studies of intrinsic and defect structure - plus optically detected nuclear resonance.
4. Two-photon absorption and four wave mixing spectroscopy - using up to three pulsed tunable dye lasers, with variable wavelength and pulse sequence timing under computer control.
5. Time-resolved high-spectral-resolution emission spectroscopy with time resolution down to <5 nanoseconds using ''boxcar'' averager or digital signal averager or Tektronix 7912AD transient digitizer and PDP-11 computer. Spectral resolution to <0.1 cm^{-1}.
6. Laser Raman spectroscopy of low-lying energy levels (far infrared to infrared energy range) nsing pnlsed lasers and single mode Ar^+ or cw dye laser.
7. Resonance Raman spectroscopy using tunable lasers with wavelengths into the ultraviolet region.
8. Absorption spectroscopy (infrared to vacnum nltraviolet) with resolution throughout the visible <0.05 cm^{-1} (<1 MHz in some regions).
9. Variable temperatures from <1.3K to 100K in several cryostats.
10. Magnetic fields to 60kG using superconducting solenoid.
11. Scanning Fabry-Perot interferometry.

Major Equipment

1. Two 600-1000 kilowatt pulsed N_2 lasers (3371 A uv - 10 nanosecond pulses). One laser pumps two tnnable organic dye laser oscillator/amplifier chains. The other pumps a third dye laser oscillator/amplifier.
2. Three pulsed, narrow-bandwidth, tunable organic dye lasers (3600 A - 9000 A, <0.05 cm^{-1} bandwidth, 5 nanosecond pulses, 20-100 kilowatt peak power). Lasers may be scanned by computer-controlled stepper motors. One laser is pressure scanned. Three etalons are available. The three dye lasers are located on a 4' x 8' NRC table which has ample space for beam handling in the photon echo and nonlinear optics experiments. Each shot of each laser may be digitized for improved signal averaging in nonlinear experiments.

3. Electronic laser delay module. Triggering of the two N_2 lasers may be controlled manually or by computer with 1 nsec resolution. Relative timing jitter <1 nsec.
4. Coherent 599-21 actively stabilized dye laser. 30 GHz scan, 1 MHz bandwidths, 50-150 mw single frequency power with R6G dye. This laser and its Ar^+ pump laser are located on a floating 4' x 10' NRC table.
5. Coherent Radiation CR6 SG 6 watt Ar^+ laser, equipped for single-longitudinal-mode (single frequency), light-regulated operation.
6. Tektronix 7912AD transient digitizer, with <800 picosecond rise time, 9 bit vertical and 9 bit horizontal resolution, interfaced to PDP11 computer for signal averaging. (Resolution to 10 psec/point).
7. Computer data acquisition system. A dedicated DEC PDP-11 computer with required interfaces and peripheral equipment for experiment control and graphic data manipulation.
8. Scanning double monochromator. A Spex 14018, 0.85 m focal length, digitally-scanned monochromator, excellent resolution (0.1 cm^{-1} and stray light rejection capabilities (holographic 1800 gr/mm gratings).
9. Scanning ultraviolet (vacuum) monochromators. McPherson model 218 0.3 m Ebert grating monochromator and model 235 0.5m Seya-Namioka grating monochromator - covering from 1000 A to the infrared.
10. Superconducting Magnet/Helium Cryostat. A variable temperature insert dewar provides adjustable temperatures from 1.3 - 100K in highly stable magnetic fields up to 60,000 gauss.
11. Variable Temperature Helium Cryostats. A glass dewar with three flat windows spaced 90^o apart reaches 1.3K. A special metal dewar with windows optimised to eliminate birefringence and stray light is under construction.
12. Digital Spectrometer Drive System. This system, using digital electronics, allows programmed and repetitive wavelength scans to be carried out automatically.
13. Gated Signal Averager. A Princeton Applied Research Model 162 dual channel boxcar averager, up to 100 picosecond resolution.
14. Signal Averager/Multichannel Scaler. A Northern Scientific NS-575 1024 channel digital signal averager/multichannel scaler.

MATERIALS PROPERTIES LABS

Rufus Cone

1. laser and optical characterization of solids.
2. laser crystals.
3. magnetic materials.
4. nonlinear optical crystals.

CURRICULUM VITAE

William Allen Hiscock

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Montana State University
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Bozeman, Montana 59715
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PERSONAL

Birthdate: October 31, 1951
Birthplace: Santa Monica, California
Social Security Number: 569-88-3698

EDUCATION

B.S.	Physics	1973	California Institute of Technology
M.S.	Physics	1975	University of Maryland
Ph.D.	Physics	1979	University of Maryland

DISSERTATION

Title: "Black Holes and Cosmic Censorship"
Abstract: Dissertation Abstracts International 40, 2236 (1980).
No. 79-25744
Advisor: Charles W. Misner

ACADEMIC POSITIONS

1988-present	Associate Professor	Physics Department, Montana State University, Bozeman, Montana
1984-1988	Assistant Professor	Physics Department, Montana State University, Bozeman, Montana
1983-1984	Postdoctoral Research Associate	Physics Department, University of California Santa Barbara, California
1982-1983	Lecturer	Physics Department, University of Texas, Austin, Texas

ACADEMIC POSITIONS (cont.)

1981-1982	Postdoctoral Research Associate	Center for Relativity, Physics Department, University of Texas, Austin, Texas
1979-1981	Research Staff Physicist	Physics Theory Group, Physics Department, Yale University, New Haven, Connecticut
1980	Visiting Postdoctoral Fellow	Quantum Gravity Program National Institute for Theoretical Physics University of California Santa Barbara, California
1976-1979	Research Assistant	Physics Department, University of Maryland, College Park, Maryland
1974-1976	Fellow	Center for Theoretical Physics, Physics Department, University of Maryland, College Park, Maryland
1973-1974	Teaching Assistant	Physics Department, University of Maryland, College Park, Maryland
1973	Teaching Assistant	Physics Department California Institute of Technology, Pasadena, California
1972	Research Assistant	High Energy Physics Group, California Institute of Technology, Pasadena, California

PUBLICATIONS

I. Refereed Scientific Papers:

"Study of the coherent reaction $K^+d \rightarrow K^0\pi^+d$ at 2 GeV/c" Nuclear Physics B52, 403 (1973). (with A. Firestone, L. Proudfoot, A. Dzierba, B. Barish, R. Gomez, R. Poster, P. Schlein, W. Slater, F. T. Dao, and E. Malamud).

PUBLICATIONS (cont.)

"Stress-energy tensor near a charged, rotating, evaporating black hole," Physical Review D15, 3054 (1977).

"On tidal interactions with Kerr black holes," The Astrophysical Journal 216, 908 (1977).

"Stress-energy tensor for a two-dimensional evaporating black hole," Physical Review D16, 2673 (1977).

"Scalar perturbations in the Gödel universe," Physical Review D17, 1497 (1978).

"Cosmic censorship, black holes, and particle orbits," General Relativity and Gravitation 10, 99 (1979).

"Post-Newtonian effects on satellite orbits near Jupiter and Saturn," The Astrophysical Journal 231, 224 (1979) (with Lee Lindblom).

"Quantum-mechanical instability of the Kerr-Newman black hole interior," Physical Review D21, 2057 (1980).

"On the topology of charged spherical collapse," Journal of Mathematical Physics 22, 215 (1981).

"Magnetic charge, black holes, and cosmic censorship," Annals of Physics 131, 245 (1981).

"Evolution of the interior of a charged black hole," Physics Letters A83, 110 (1981).

"Models of evaporating black holes. I.," Physical Review D23, 2813 (1981).

"Models of evaporating black holes. II. Effects of the outgoing created radiation," Physical Review D23, 2823 (1981).

"On black holes in magnetic universes," Journal of Mathematical Physics 22, 1828 (1981).

"Criticism of some nonconservative gravitational theories," Journal of Physics A15, 1827 (1982) (with Lee Lindblom).

"Creation of particles by shell-focusing singularities," Physical Review D26, 751 (1982) (with D. Eardley and L. Williams).

"Quantum vacuum energy in Taub-NUT-type cosmologies," Physical Review D26, 1225 (1982) (with D. Konkowski).

"On axisymmetric perturbations of some rotating stars," The Astrophysical Journal 266, 248 (1983).

PUBLICATIONS (cont.)

"On the stability of rotating stellar models in general relativity theory," The Astrophysical Journal 267, 384 (1983) (with Lee Lindblom).

"Magnetic monopoles and evaporating black holes," Physical Review Letters 50, 1734 (1983).

"Stability and causality in dissipative relativistic fluids," Annals of Physics 151, 466 (1983) (with Lee Lindblom).

"Gravitational creation of particles by a vacuum bubble," Physics Letters B139, 31 (1984).

"Generic instabilities in first-order dissipative relativistic fluid theories," Physical Review D31, 725 (1985) (with Lee Lindblom).

"Exact gravitational field of a string," Physical Review D31, 3288 (1985).

"Quantum instabilities and the cosmological constant," Physics Letters B166, 285 (1986).

"Generic instabilities in first-order dissipative relativistic fluid theories. II. Havas-Swenson-type theories," Physical Review D33, 1527 (1986).

"Can black holes nucleate vacuum phase transitions?" Physical Review D35, 1161 (1987).

"Semiclassical gravitational effects near cosmic strings," Physics Letters B188, 317 (1987).

"The problem of dissipation in relativistic fluids," in Proceedings of the 13th Texas Symposium on Relativistic Astrophysics, ed. by M. Ulmer (World Scientific, Singapore, 1987) p. 117 (with Lee Lindblom).

"Linear plane waves in dissipative relativistic fluids," Physical Review D35, 3723 (1987) (with Lee Lindblom).

"General relativistic fluid spheres with nonzero vacuum energy density," Journal of Mathematical Physics, 29, 443 (1988).

"Relativistic fluid flows around cosmic strings," Physical Review, D37, 869 (1988) (with J. Bryan Lail).

"Stability in dissipative relativistic fluid theories," in Contemporary Mathematics 71, 181 (1988), (with Lee Lindblom).

"Gravitational vacuum polarization around static spherical stars," Physical Review D37, 2142 (1988).

PUBLICATIONS (cont.)

"A one-fluid model of superfluids," Physics Letters 131A, 280 (1988), (with Lee Lindblom).

"Nonlinear pathologies in relativistic heat-conducting fluid theories," Physics Letters 131A, 509 (1988), (with Lee Lindblom).

"Quantum instability of gravitational collapse in de Sitter space," Phys. Rev. D35, 1067 (1989).

"Gravitational nucleation of vacuum phase transitions by compact objects," Phys. Rev. D35, 1537, (1989), (with Gregory Mendell).

"Relativistic dissipative hydrodynamics and the nuclear equation of state," Physical Review C39, 1818 (1989) (Timothy S. Olson).

"Quantum corrections to Kepler's third law," in Proceedings of the 5th Marcel Grossman Meeting, ed. by D. Blair (World Scientific, Singapore, 1989).

"Gravitational particle production during cosmic string formation in the sudden approximation," Physical Review D40, 282 (1989) (with Gregory Mendell).

"Some properties of dissipative relativistic fluid theories," in Relativistic Fluid Dynamics, ed. by A. Anile (Springer-Verlag, Berlin, 1989) (with Lee Lindblom).

"Gravitational entropy of nonstationary black holes and spherical shells," Physical Review D40, 1336 (1989).

"Effects of frame choice on nonlinear dynamics in relativistic heat-conducting fluid theories," Physics Letters A141, 125 (1989) (with Timothy S. Olson).

"Evolution of charged evaporating black holes," Physcal Review D4, 1142 (1989) (with Lance D. Weems).

"Gravitational particle creation by spherical oscillations," Classical and Quantum Gravity 7, L35 (1990).

"Gravitational particle production in the formation of global monopoles," Physics Letters B234, 469 (1990).

"Astrophysical Bounds on Global Monopoles," Physical Review Letters 64, 344 (1990).

"Stability, causality, and hyperbolicity in Carter's theory in relativistic heat-conducting fluids," Physical Review D41, 3687 (1990) (with Timothy S. Olson).

PUBLICATIONS (cont.)

"Quantum effects of domain wall formation in the early universe," Physical Review D41, 3604 (1990) (with Paul Anderson and Richard Holman).

"Plane Steady Shock Waves in Israel-Stewart Fluids," Annals of Physics (in press) (with Timothy S. Olson).

"Semiclassical Gravitational Effects Around Global Monopoles," submitted to Classical and Quantum Gravity Letters (in press).

II. Book Reviews, Letters of Comment, etc.:

Letter of comment: "Time travel" Science Digest 90, 8 (1982).

Book Review: "Black Holes, White Dwarfs, and Neutron Stars: The Physics of Compact Objects" by Stuart L. Shapiro and Saul A. Teukolsky; American Scientist 72, 504 (1984).

Book Review: "Cosmology and Astrophysics" edited by Y. Terzian and E.M. Bilson; Foundations of Physics 15, 1071 (1985).

Book Review: "The Very Early Universe" edited by G.W. Gibsons, S.W. Hawking, and S.T.C. Siklos; Foundations of Physics 16, 1221 (1986).

ACADEMIC AWARDS AND HONORS

Honorable mention, Gravity Research Foundation Essay Contest
1977: "Quantum mechanical instability of black hole interiors".
1982: "Quantum vacuum energy in Taub-NUT-like cosmologies".

Third Prize, Gravity Research Foundation Essay Contest
1978: "Cosmic censorship, black holes, and particle orbits".

Center for Theoretical Physics Fellowship, 1974-1976

Phi Kappa Phi, elected to membership, 1977

Sigma Xi, elected to membership, 1985

MEMBERSHIPS AND POSITIONS IN PROFESSIONAL SOCIETIES

Member of the American Physical Society
Member of Sigma Xi
Member of Montana Section, American Association of Physics Teachers
Vice President, Montana State University Chapter of Sigma Xi (1988 - 89)
President, Montana State University Chapter of Sigma Xi (1989 - 90)

OTHER PROFESSIONAL ACTIVITIES

Reviewer of manuscripts for Physical Review Letters, Physical Review D, Journal of Mathematical Physics, Journal of General Relativity and Gravitation, Foundations of Physics, Il Nuovo Cimento, Classical and Quantum Gravity, Annals of Physics.

Reviewer of books for American Scientist, Foundations of Physics.

Reviewer of book manuscripts for Academic Press, West Publishing Co.

Reviewer of proposals for Gravitational Physics Section, National Science Foundation.

MSU chapter advisor, Society for Physics Students and Sigma Pi Sigma (National physics honorary fraternity) (1986 - 1989)

MEETINGS ATTENDED AND PAPERS PRESENTED

7th Texas Symposium on Relativistic Astrophysics, Dallas, Texas, December 1974.

8th Texas Symposium on Relativistic Astrophysics, Boston, Massachusetts, December 1976.

Spring Meeting of the American Physical Society, Washington, D.C., April 1977, "Black Hole Interiors and the Hawking Process" (contributed paper).

8th InternationalConference on General Relativity and Gravitation, Waterloo, Ontario, Canada, August 1977, "Cosmic Censorship at work: Magnetic Monopoles and Reissner-Nordstrom Black Holes" (contributed paper).

Spring Meeting of the American Physical Society, Washington, D.C., April 1978, "Black Holes and Cosmic Censorship" (contributed paper).

Battelle Summer Workshop on Sources of Gravitational Radiation, July 24-August 4, 1978.

Spring Meeting of the American Physical Society, Washington, D.C., April 1979, "Measuring the Post-Newtonian Gravitational Fields of the Gas Giant Planets" (contributed paper).

MEETINGS ATTENDED AND PAPERS PRESENTED (cont.)

10th Texas Symposium on Relativistic Astrophysics, Baltimore, Maryland, December 1980.

"Fezafest," Symposium in honor of Feza Gursey, Yale University, April 1981.

Symposium in honor of Bryce S. DeWitt, University of Texas, Austin, Texas, December 1982.

11th Texas Symposium on Relativistic Astrophysics, Austin, Texas, December 1982.

10th International Conference on General Relativity and Gravitation, Padova, Italy, July 1983, "Magnetic Monopoles and Evaporating Black Holes" (invited workshop paper) and "Stability and Causality in Dissipative Relativistic Fluids" (contributed paper).

Syracuse Discussion Conference on Classical and Quantum Gravity, Syracuse, New York, April 1985, "Stability and Causality in Dissipative Relativistic Fluids" (invited lecture).

Second Annual Meeting (New Series) of the Division of Particles and Fields of the American Physical Society; Eugene, Oregon, August, 1985, "Constraints on Quantum Instabilities of the Cosmological Constant" (contributed paper).

Workshop on "Approaches to Quantum Gravity," Institute for Theoretical Physics, University of California at Santa Barbara, June 1986.

AMS/IMS/SIAM Joint Summer Research Conference: Mathematics in General Relativity,June 1986,University of California at Santa Cruz, "Stability and Causality in Dissipative Relativistic Fluids" (invited lecture).

11th International Conference on General Relativity and Gravitation, Stockholm, Sweden, July 1986.

Fall meeting of the Montana Section, AAPT, Oct. 16-17, 1986, Bozeman, Montana. "The Expanding Universe" (invited talk).

13th Texas Symposium on Relativistic Astrophysics, Chicago, Illinois, 14-19 December, 1986.

AAPT Summer Meeting; Bozeman, Montana, June 1987, "The Standard Model of the Universe," (invited lecture).

Physics Teaching Resource Agents meeting, Bozeman, Montana, June 1987, "A Quick History of the Universe," (invited lecture).

MEETINGS ATTENDED AND PAPERS PRESENTED (cont.)

Workshop on high temperature QCD and relativistic many-body theory; University of Minnesota Theoretical Physics Institute, October 1987, "Properties of Relativistic Dissipative Fluid Theories," (invited lecture).

Fall meeting of the Montana section, AAPT; Billings, Montana, October 1987, "The New Supernova," (invited talk).

5th Marcel Grossmann meeting; Perth, Australia, August 1988. "Gravitational nuclear equation of vacuum phase transitions," (invited lecture). "Nonlinear pathologies in relativistic heat-conducting fluid theories," (contributed talk). "Quantum corrections to Kepler's third law," (poster).

14th Texas Symposium on Relativistic Astrophysics; Dallas, Texas, December 1988. "Relativistic fluid flows around cosmic strings," (poster; with J. Bryan Lail). "Gravitational particle production during cosmic string formation in the sudden approximation," (poster; with G. Mendell).

12th International Conference on General Relativity and Gravitation, Boulder, Colorado, July 1989. "Formation of domain walls in the early universe" (invited lecture); "Gravitational Particle production during cosmic string formation in the sudden approximation" (poster; with Gregory Mendell); "Linear stability of equilibria in Carter's theory of relativistic heat conducting fluids" (poster; with Timothy Olson).

COMMITTEE ASSIGNMENTS

Physics Department Library Representative	1984-1986
Physics 101 Representative on Departmental Core Curriculum Committee	1984-1985
Physics Department Exam Committee	1985-1986; 1988; 1989-
Physics Department P and P Committee	1985-1986; 1987-88; 1990-91
Physics Department Graduate Recruitment Committee	1986-1989
Physics Department SPS Adviser	1986-1989
Physics Department Freshman Class Advisor	1987-1989
Physics Department Sophomore Class Advisor	1988-1989
Physics Department Junior Class Advisor	1989-1990
Physics Department Senior Class Advisor	1990-1991
Physics Department Graduate Committee	1988-1989
Physics Department Long Range Planning Committee	1989-
Physics Department Computer Committee	1990-

RESEARCH CONTRACTS OR GRANTS DIRECTED

Agency	Title	Dates	Amount	Status
MSU Faculty Research-Creativity	"Research in Relativistic Astrophysics"	1985-86	$2,500	Approved
National Science Foundation	"Research in General Relativity and Relativistic	1985-88	$52,436	Approved
MONTS	"Relativistic Dissipative Fluid Mechanics"	1985-86	$8,180	Approved
National Science Foundation	"Research in Gravitation Theory" (co-principal investigator with L. Lindblom and K. Nordtvedt)	1987-89	$52,000	Approved
National Science Foundation	"Research in Gravitation Theory and Relativistic Physics"	1988-92	$130,400	Approved
MONTS	"Gravitation and Superconducting Cosmic Strings"	1988-89	$9,700	Approved
EPSCoRII	"Research in Gravitation Theory and Theoretical Astrophysics" (co-principal investigator with S. Tsuruta)	1990-92	$194,850	Approved
NASA	"Montana Space Grant Consortium"	1991-94	$600,000	Submitted

Curriculum Vitae

LEE LINDBLOM

Physics Department
Montana State University
Bozeman, MT 59717

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Bozeman, MT 59715

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Birthdate: March 25, 1950
Birthplace: San Francisco, California
Social Security Number: 549-70-5193

EDUCATION

B.S. (Physics)	1972	California Institute of Technology
M.S. (Physics)	1975	University of Maryland at College Park
Ph.D. (Physics)	1978	University of Maryland at College Park

Dissertation: "Fundamental Properties of Equilibrium Stellar Models"
Abstract: *Dissertation Abstracts International*, **39B**, 4409 (1979).
Advisor: Dieter R. Brill

ACADEMIC POSITIONS

1988 -	Associate Professor	Physics Dept., Montana State University
1985 - 1988	Assistant Professor	Physics Dept., Montana State University
1984 - 1985	Research Associate	Enrico Fermi Institute, Univ. of Chicago
Fall 1983	A.H. Compton Lecturer	Enrico Fermi Institute, Univ. of Chicago
1982 - 1984	Enrico Fermi Fellow	Enrico Fermi Institute, Univ. of Chicago
Spring 1982	Lecturer	Physics Department, Stanford University
1980 - 1982	Research Associate	Physics Department, Stanford University
1978 - 1980	Research Physicist	Physics Dept., Univ. of Calif., Santa Barbara

PUBLICATIONS

"The Crystal and Molecular Structure of μ-Peroxo-bis-[3,3'-diimino-di-n-propylamine-bis-salicylaldehyde Cobalt(III)]·$C_6H_5CH_3$," *Acta Crystallographica*, **B27**, 1461 (1971) with W.P. Schaefer and R.E. Marsh.

"Variances and Covariances of the Anisotropic Temperature Parameters," *Acta Crystallographica*, **B28**, 2198 (1972) with R.E. Marsh and J. Waser.

"Inertial Effects in the Gravitational Collapse of a Rotating Shell," *Physical Review*, **D10**, 3151 (1974) with D.R. Brill.

PUBLICATIONS (continued)

"Comment on Malin's Theory of Gravity," *Physical Review*, D12, 626 (1975) with J.M. Nestor.

"Stationary Stars are Axisymmetric," *The Astrophysical Journal*, 208, 873 (1976).

"On the Analyticity of Certain Stationary Nonvacuum Einstein Spacetimes," *Journal of Mathematical Physics*, 17, 1810 (1976).

"On the Secular Instabilities of the Maclaurin Spheroids," *The Astrophysical Journal*, 211, 565 (1977) with S.L. Detweiler.

"On the Evolution of the Homogeneous Ellipsoidal Figures," *The Astrophysical Journal*, 213, 193 (1977) with S.L. Detweiler.

"Mirror Planes in Newtonian Stars with Stratified Flows," *Journal of Mathematical Physics*, 18, 2352 (1977).

"On the Determination of Cauchy Surfaces from Intrinsic Properties," *Communications in Mathematical Physics*, 61, 87 (1978) with R. Budic, J. Isenberg and P.B. Yasskin.

"Post-Newtonian Effects on Satellite Orbits Near Jupiter and Saturn," *The Astrophysical Journal*, 231, 224 (1979) with W.A. Hiscock.

"The Role of Neutrino Dissipation in Gravitational Collapse," *The Astrophysical Journal*, 232, 974 (1979) with S. Detweiler.

"On the Secular Instability from Thermal Conductivity in Rotating Stars," *The Astrophysical Journal*, 233, 974 (1979).

"Comments on the Topology of Nonsingular Stellar Models," in *Essays in General Relativity: A Festschrift for Abraham Taub*, edited by Frank Tipler (Academic Press: 1980) 13-19, with D.R. Brill.

"Some Properties of Static General Relativistic Stellar Models," *Journal of Mathematical Physics*, 21, 1455 (1980).

"Some Properties of Static General Relativistic Stellar Models II," *Journal of Mathematical Physics*, 22, 1324 (1981).

"On the Evolution of the Homogeneous Ellipsoidal Figures II: Gravitational collapse and Gravitational Radiation," *The Astrophysical Journal*, 250, 739 (1981) with S. Detweiler.

"Criticism of Some Non-conservative Gravitational Theories," *Journal of Physics*, A15, 1827 (1982) with W.A. Hiscock.

"On the Stability of Rotating Stellar Models in General Relativity Theory," *The Astrophysical Journal*, 267, 384 (1983) with W.A. Hiscock.

PUBLICATIONS (continued)

"Necessary Conditions for the Stability of Rotating Newtonian Stellar Models," *The Astrophysical Journal*, **267**, 402 (1983).

"The Quadrupole Oscillations of Neutron Stars," *The Astrophysical Journal Supplement Series*, **53**, 73 (1983) with S.L. Detweiler.

"The Radial Oscillations of Neutron Stars," *The Astrophysical Journal Supplement Series*, **53**, 93 (1983); **71**, 173 (1989) with E.N. Glass.

"Stability and Causality in Dissipative Relativistic Fluids," *Annals of Physics*, **151**, 466 (1983) with W.A. Hiscock.

"Limits on the Gravitational Redshift from Neutron Stars," *The Astrophysical Journal*, **278**, 364 (1984).

"Generic Instabilities in First Order Dissipative Relativistic Fluid Theories," *Physical Review*, **D31**, 725 (1985) with W.A. Hiscock.

"The Accuracy of the Quadrupole Approximation for the Gravitational Radiation from Pulsating Stars," *Monthly Notices of the Royal Astronomical Society*, **213**, 553 (1985) with E. Balbinski, S. Detweiler and B.F. Schutz.

"On the Nonradial Pulsations of General Relativistic Stellar Models," *The Astrophysical Journal*, **292**, 12 (1985) with S.L. Detweiler.

"Is Perturbation Theory Misleading in General Relativity?" *Journal of Mathematical Physics*, **26**, 2581 (1985) with R. Geroch.

"Estimates of the Maximum Angular Velocity of Rotating Neutron Stars," *The Astrophysical Journal*, **303**, 146 (1986).

"The Effect of Viscosity on Neutron Star Oscillations," *The Astrophysical Journal*, **314**, 234 (1987) with C. Cutler.

"The Role of the Viscous Secular Instability in Rotating Neutron Stars," *The Astrophysical Journal*, **317**, 325 (1987).

"The Problem of Dissipation in Relativistic Fluids," in *13th Texas Symposium on Relativistic Astrophysics*, ed. by M.P. Ulmer (World Scientific: 1987) 117-121 with W.A. Hiscock.

"Linear Plane Waves in Dissipative Relativistic Fluids," *Physical Review*, **D35**, 3723 (1987) with W.A. Hiscock.

"Stability in Dissipative Relativistic Fluid Theories," (Mathematics and General Relativity) *Contemporary Mathematics*, **71**, 181 (1988) with W.A. Hiscock.

"Static Uniform-Density Stars Must be Spherical in General Relativity," *Journal of Mathematical Physics*, **29**, 436 (1988).

PUBLICATIONS (continued)

"Gravitational Radiation From Instabilities in Rapidly Rotating Neutron Stars?" in *International Symposium on Experimental Gravitational Physics*, ed. by P. F. Michelson (World Scientific: 1988) pp. 276-282.

"A One-Fluid Model of Superfluids," *Physics Letters*, A131, 280 (1988) with W.A. Hiscock.

"Nonlinear Pathologies in Relativistic Heat-Conducting Fluid Theories," *Physics Letters*, A131, 509 (1988) with W.A. Hiscock.

"Pulsar Evolution," *Nature*, 339, 19 (1989) with W. Kluźniak, P. Michelson and R. V. Wagoner.

"Oscillations and Stability of Rapidly Rotating Neutron Stars," *Physical Review Letters*, 62, 2777 (1989); 63, 1327 (1989) with J. R. Ipser.

"The Dipole Oscillations of General Relativistic Neutron Stars," *The Astrophysical Journal*, 345, 925 (1989) with R. J. Splinter.

"The Accuracy of the Relativistic Cowling Approximation," *The Astrophysical Journal*, 348, 198 (1990) with R. J. Splinter.

"Dissipative Relativistic Fluid Theories of Divergence Type," *Physical Review D*, 41, 1855 (1990) with R. Geroch.

"The Oscillations of Rapidly Rotating Newtonian Stellar Models," *The Astrophysical Journal*, in press (1990) with J. R. Ipser.

"Improving the Accuracy of WKB Eigenvalues," *Journal of Mathematical Physics*, submitted (1990) with R. T. Robiscoe.

"Damping Times for Neutron Star Oscillations," *The Astrophysical Journal*, submitted (1990) with C. Cutler and R. J. Splinter.

"The Coupling of Charged Superfluid Mixtures to the Electromagnetic Field, "*Annals of Physics*, submitted (1990) with G. Mendell.

PROFESSIONAL MEETINGS

Seventh Texas Symposium on Relativistic Astrophysics, Dallas, Texas, December 16-20, 1974.

American Physical Society Winter Meeting, New York, NY, February 2-5, 1976, contributed talk, "Stationary Stars are Axisymmetric."

American Physical Society Spring Meeting, Washington, D.C., April 26-29, 1976, contributed talk, "On the Evolution of Homogeneous Newtonian Ellipsoidal Figures," with S.L. Detweiler.

Eighth Texas Symposium on Relativistic Astrophysics, Boston, Massachusetts, December 13-17, 1976.

Eighth International Conference on General Relativity and Gravitation, Waterloo, Ontario, Canada, August 7-12, 1977, contributed paper, "On the Determination of Cauchy Surfaces From Intrinsic Properties," with R. Budic, J. Isenberg and P. Yasskin.

Workshop on Gravitational Wave Sources, Seattle, Washington, July 24 - August 4, 1978.

American Physical Society Spring Meeting, Washington, D.C., April 23-26, 1979, contributed talks, "Gravitational Waves From Gravitational Collapse." with S.L. Detweiler, and, "Measuring the Post-Newtonian Gravitational Fields of the Gas Giant Planets," with W.A. Hiscock.

Ninth International Conference on General Relativity and Gravitation, Jena, German Democratic Republic, July 14-19, 1980, contributed paper, "Static Uniform Density Stellar Models Must be Spherical."

Tenth Texas Symposium on Relativistic Astrophysics, Baltimore, Maryland, December 1980.

Eleventh Texas Symposium on Relativistic Astrophysics, Austin, Texas, December 12-17, 1982.

Tenth International Conference on General Relativity and Gravitation, Padova, Italy, July 4-9, 1983, contributed paper, "Stability and Causality in Dissipative Relativistic Fluids," with W.A. Hiscock.

Mathematics and General Relativity, Santa Cruz, California, June 22-28, 1986.

Eleventh International Conference on General Relativity and Gravitation, Stockholm, Sweden, July 6-12, 1986.

Thirteenth Texas Symposium on Relativistic Astrophysics, Chicago, Illinois, December 14-20, 1986, invited talk, "The Problem of Dissipation in Relativistic Fluids."

Relativistic Fluid Dynamics, Noto, Italy, May 25 - June 3, 1987, invited talk, "Some Properties of Dissipative Relativistic Fluid Theories."

PROFESSIONAL MEETINGS (continued)

American Association of Physics Teachers Summer Meeting, Bozeman, Montana, June 17-19, 1987, invited research tutorial, "Black Holes, White Dwarfs and Neutron Stars."

International Symposium on Experimental Gravitational Physics, Guangzhou, China, August 3-8, 1987, contributed talk, "Gravitational Radiation From Instabilities in Rotating Neutron Stars?"

Fourteenth Texas Symposium on Relativistic Astrophysics, Dallas, Texas, December 11-16, 1988.

Twelfth International Conference on General Relativity and Gravitation, Boulder, Colorado, July 2-8, 1989, contributed talk, "Pulsations and Stability of Rotating Stellar Models," (with J. Ipser).

Sixth Pacific Coast Gravity Conference, Eugene, Oregon, March 30-31, 1990, contributed talk, "Dissipative Relativistic Fluid Theories of Divergence Type."

SEMINARS AND COLLOQUIA

October 11, 1978, "Fundamental Properties of Equilibrium Stellar Models," California Institute of Technology.

May 1, 1979, "Secular Instability From Thermal Conductivity in Rotating Stars," Harvard University.

May 15, 1979, "Secular Instability From Thermal Conductivity in Rotating Stars," University of Chicago.

October 19, 1979, "Secular Instability From Thermal Conductivity in Rotating Stars," California Institute of Technology.

February 22, 1980, "Why Stars are Round," Stanford University.

November 17, 1980, "Fundamental Properties of Equilibrium Stellar Models", University of California at Berkeley.

December 2, 1981, "On the Stability of Rotating Stars," University of California at Berkeley.

February 9, 1982, "On the Stability of Rotating Stars," NASA Ames Research Center.

October 19, 1982, "Does Heat Flow Make Sense in Relativity Theory?" Syracuse University.

October 20, 1982, "On the Stability of Rotating Stars in General Relativity", Syracuse University.

November 23, 1982, "Does Heat Flow Make Sense in Relativity Theory?" University of Wisconsin at Milwaukee.

December 7, 1982, "Does Heat Flow Make Sense in Relativity Theory?" University of Florida.

January 25, 1983, "Does Heat Flow Make Sense in Relativity Theory?" University of California at Santa Barbara.

April 29, 1983, "Does Heat Flow Make Sense in Relativity Theory?" University of Windsor.

September 7, 1983, "Limits on the Gravitational Redshift From Neutron Stars," University of Florida.

September 12, 1983, "Stability and Causality in Dissipative Relativistic Fluids," University of North Carolina.

September 14, 1983, "Stability and Causality in Dissipative Relativistic Fluids," University of Maryland at College Park.

September 15, 1983, "Limits on the Gravitational Redshift From Neutron Stars," University of Maryland at College Park.

January 5, 1984, "Testing the Quadrupole Formula," University of California at Santa Barbara.

February 28, 1984, "Does Heat Flow Make Sense in Relativity Theory?" Montana State University.

March 9, 1984, "Does Heat Flow Make Sense in Relativity Theory?" University of California at San Diego.

April 17, 1984, "The Problem of Heat Flow in Relativistic Fluids," University of Pittsburgh.

January 8, 1985, "The Relativity - Heat Flow Paradox," University of Oregon.

January 9, 1985, "Sizing up Neutron Stars," University of Oregon.

January 15, 1985, "Sizing up Neutron Stars," Montana State University.

March 10, 1987, "The Problem of Dissipation in Relativistic Fluids," University of Florida.

March 22, 1987, "The Problem of Dissipation in Relativistic Fluids," University of Utah.

March 18, 1988, "Static Uniform-Density Stars are Spherical," University of Florida.

May 3, 1988, "Instabilities in Rapidly Rotating Neutron Stars," Stanford University.

May 20, 1988, "Instabilities in Rapidly Rotating Neutron Stars," University of California at Santa Barbara.

SEMINARS AND COLLOQUIA (continued)

November 16, 1988, "Instabilities in Rapidly Rotating Neutron Stars," University of Wisconsin at Milwaukee.

November 18, 1988, "Instabilities in Rapidly Rotating Neutron Stars," University of Chicago.

February 16, 1989, "Instabilities in Rapidly Rotating Neutron Stars," University of Florida.

March 31, 1989, "Non-axisymmetric Oscillations of Rotating Stars," University of Chicago.

May 10, 1989, "Instabilities in Rapidly Rotating Neutron Stars," California Institute of Technology.

January 12, 1990, "Dissipative Relativistic Fluid Theories of Divergence Type," University of Chicago.

January 16, 1990, "Dissipative Relativistic Fluid Theories of Divergence Type," University of Wisconsin at Milwaukee.

PUBLIC SERVICE ACTIVITIES

Public Lecture Series: "White Dwarfs, Neutron Stars and Black Holes," University of Chicago, October 10 - December 10, 1983 (ten lectures).

Lecturer, Adler Planetarium, Chicago, Illinois, 1984-85.

OTHER PROFESSIONAL ACTIVITIES

Member: American Astronomical Society

Referee for:

The Physical Review D	The Astrophysical Journal
Science	Journal of Math. Physics
National Science Foundation	The Physical Review Letters
Nature	Communications in Math. Physics
Physics Letters A	Classical and Quantum Gravity
Mon. Not. Royal Astro. Society	American Journal of Physics

Organizing Committee for "Mathematics and General Relativity," American Mathematical Society Conference, Santa Cruz, California, June 22-28, 1986.

RESEARCH GRANTS

Agency	Title	Dates	Amounts*
NSF	Research in Gravitation Theory and Astrophysics	1985-1990	$402,639
NSF	Research in Gravitation Theory (with W. Hiscock and K. Nordtvedt)	1987-1989	$73,746
MONTS	The Effects of Superfluidity on Neutron Star Oscillations	1989-1990	$11,500

* To date including university matching funds.

COURSES TAUGHT

Phys 192 (Stanford)	Senior Seminar: Basic Gravitation	S 82
Phys 311 (MSU)	General Astronomy	F 85
Phys 312 (MSU)	General Astronomy II	W 88, W 89
Phys 515 (MSU)	Frontiers of Physics: Black Holes, White Dwarfs and Neutron Stars	S 86
Phys 519 (MSU)	Maxwell's Equations	F 86
Phys 523 (MSU)	Einstein's Equations	F 87, F 89
Phys 568 (MSU)	Approximation Methods of Physics	S 87

KENNETH L. NORDTVEDT, JR.

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Bozeman, Montana 59715
Telephone: (406) 586-3263

PERSONAL

Birthdate: April 16, 1939
Social Security Number: 319-30-6696

EDUCATION

B.S., Physics, 1960, Massachusetts Institute of Technology
M.S., Physics, 1962, Stanford University
Ph.D., Physics, 1964, Stanford University
Post-Doc, Physics, 1963-65, Harvard University

PREVIOUS POSITIONS AND EXPERIENCE

1963-1965	Physics Staff	MIT Instrumentation Laboratory
1963-1965	Post-Doc	Harvard University
1963-1965	Physicist	Project Apollo
1958	Physicist	Lockheed Aircraft
1960	Physicist	Los Alamos Scientific Laboratory
1965	Assistant Professor	Montana State University
1967	Associate Professor	Montana State University
1970-1988	Professor	Montana State University
1979-1984	Representative	Montana House of Representatives
1983	Consultant	Department of Energy
1988-	Professor Emeritus	Montana State University
1987-	Board Member	National Science Foundation
1989-	Director of Revenue	State of Montana

PUBLICATIONS

Mass Inst. of Tech. Instr. Lab. Report E-851, A Heated Ammonia Propulsion System (1959).

Annals of Physics, 17, Electromagnetic Plane Wave Solutions in General Relativity (1962).

Mass. Inst. of Tech. Instr. Lab. Report E-1540, A Preliminary Study of a Back-Up Manual Navigation Scheme (1964).

Stanford Microwave Laboratory Report 1322, Applications of the Equation of Motion Method to the Electron-Phonon System (1965).

PUBLICATIONS (cont.)

NASA Contractor's Report CR-841 A Theory of Manual Space Navigation (1967).AIAA Journal 5, 1185, An Approach to Manual Space Navigation (1967).

Jour. Math. Phys. 8, 1406, Upper Bounds to Eigenvalues of the One- Dimensional Sturm-Liouville Equation (1967). Kenneth L. Nordtvedt, Jr.

Phys. Rev. 173, 547, Low Temperature Effects of the Tunneling Integral in Hydrogen-Bonded Ferroelectrics (1968).

Amer. Jour. Phys. 36, 162, Isotopic Mass Dependence of Sound Velocities (1968).

Phys. Rev. 169, 1014, Equivalence Principle for Massive Bodies I, Phenomenology (1968).

Phys. Rev. 169, 1017, Equivalence Principle for Massive Bodies II, Theory (1968).

Phys. Rev. 170, 1186, Testing Relativity with Laser Ranging to the Moon (1968).

Phys. Rev. 180, 1293, Equivalence Principle for Massive Bodies Including Rotational Energy and Radiation Pressure (1969).

Gravity Research Institute, 1969 3rd Prize Essay. Testing Einstein's Inhomogeneous Gravitational Field Equations (1969).

Phys. Rev. 186, 1352, Back Reflection of Scalar and Vector Waves in Gravitational Fields (1969).

Icarus 12, 91, Solar System Eotvos Experiments (1969).

International Journal of Theor. Physics 3, 133, Gravitational and Inertial Mass of Bodies of Interacting Electrical Charges (1969).

Astrophysical Jour. 161, 1059, Post-Newtonian Metric for a General Class of Scalar-Tensor Gravitational Theories and Observational Consequences (1970).

Phys. Rev.B1, 81, Quantum Electrodynamic Corrections to the Electron Charge Value in Metals (1970).

Tests of the Equivalence Principle and Gravitation Theory Using Solar System Bodies Proceedings of the Conference on Experimental Tests of Gravitation Theories Nov. 11-13, 1970 California Inst. of Tech (1970).

Phys. Rev. 3, 8, 1683, Equivalence Principle for Massive Bodies IV, Planetary Bodies and Laboratory Experiments (1971).

Solution of the Maxwell Equations for a Static Distribution of Massive Charged Particles, G.R.G. Journal, 3, 2 (1972) 95.

Conservative Laws and Preferred Frames in Relativistic Gravity I. Preferred-Frame Theories and an Extended PPN Formalism (with C. Will) Astrophysical Journal, 177 757-774 (1972).

PUBLICATIONS (cont.)

Gravitation Theory, Empirical States from Solar System Experiments: Science 178, (1972) 1157.

Conservation Laws.....II. Experimental Evidence to Rule Out Preferred- Frame Theories of Gravity (with C. Will) Astrophysical Journal, 177: 775-792, 1972.

A Vector-Metric Theory of Gravity (with R. Hellings) Phys. Rev. D7, 12 (1973) 3593.

Post-Newtonian Gravitational Effects in Lunar Laser Ranging; Phys. Rev. D7, 8 (1973) 2347.

Causality in a Two-Metric Theory of Gravity, AIP Proceedings No. 16, W. B. Rolnick, editor.

Gravity, 1974 edition of Encyclopiedia Brittanica.

Equation of Motion for Non-Geodesic Laboratory Bodies, Int. J.T.P. 9, 4 (1974).

The Equivalence Principle and the Question of Weight, A.J.P.43, 3 (1975).

Quantitative Relationship Between Clock Gravitational "Red Shift" Violations and Nonuniversality of Free-Fall Rates in Non-Metric Theories of Gravity, Physical Review D11, 2, January, (1975).

Anisotropic Gravity and the Binary Pulsar, Astrophysics Journal, November (1975).

Clocks and the Equivalence Principle, The Rollins Seminar on Theoretical & Experimental Aspects of the Principle of Equivalence, Smithsonian Observatory September 25 (1975).

"Anisotropic Parametrized Post-Newtonian Gravitational Metric Field," K. Nordvedt, Jr. Phys. Rev. D14, 6, 15 Sept. (1976).

Ohanian Gravitation and Spacetime," Book review in American J. of Physics, 45/3, 317 (1977).

A Study of One and Two Way Doppler Tracking of a Clock on an Arrow Toward the Sun, (Accordenia Nagonale, Dei Lucei) (1977).

Theoretical Significance of the Lunar Laser Ranging Results, (Accordenia Nazronal Dei Lucei) (1977).

"4th Test of General Relativity," major review paper commissioned by a British journal, Progress In Physics 45, November (1982).

"Relativistic Tidal Forces," Ap. J. (1983) 264.

"Post Newtonian Gravitational Lagrangian Formalism for Celestial Body Dynamics in Metric Gravity," Astrophys. Journal, 297, 1985.

"Doppler Tracking of a Deep Space Geodesic Clock as a Test of the Metric Nature of Cosmological Space-Time," Astrophys. Ltrs, 1985.

PUBLICATIONS (cont.)

"A Post-Newtonian Gravitational Lagrangian Formalism for Celestial Body Dynamics in Metric Gravity," Astrophysical Journal, 297, 2 (1985) 390-404.

"A Possible Semisecular Variation in Orbital Period of Binary Pulsar System PSR 1913+16 and Lorentz Invariance of Gravity," The Astrophysical Journal, 322, 288-290 (1987).

"Probing Gravity to the Second Post-Newtonian Order and to One Part in 10^7 Using the Spin Axis of th Sun," The Astrophysical Journal, 320, 871 (1987).

"A Many-Body Lagrangian for Celestial Body Dynamics to Second Post-Newtonian Linear Field Order," M. Benacquista and K. Nordtvedt, The Astrophysical Journal, 328, 588-593 (1988).

"Gravitomagnetic Interaction and Laser Ranging to Earth Satellites," K. Nordtvedt, Phys. Rev. Lett., 61, 2647 (1988).

"Existence of the Gravitomagnetic Interaction," K. Nordtvedt, Intl. J. Theoretical Phys., 27, 1395 (1988).

PAPERS SUBMITTED OR IN PREPARATION

"Theoretical Importance of Lunar Laser Ranging," Proceedings of 1981 NATO Workshop on Exp. Grav. and Quantum Non-Dem.

"The Spin Axes of the Sun and Fast Pulsars: Implications for the Lorentz Invariance of Gravity," submitted to Gravity Research Foundation.

MEMBERSHIPS AND POSITIONS IN PROFESSIONAL SOCIETIES

American Physical Society
Sigma Xi
Appointed by President Reagan to be on the National Science Board

OTHER PROFESSIONAL ACTIVITIES

A variety of colloquium, seminars, lecture series, contributed and invited papers have been given at universities and professional meetings.

Approximately 12 APS Meetings.

Annual Conference on Experimental Gravity - 1969-1974.

International Conference on General Relativity and Gravity - 1971, 1974, 1980.

Conference on Casuality and Physical Theories - May 1973.

Texas Conference on Rel. Astrophysics - 1970-1973.

OTHER PROFESSIONAL ACTIVITIES (cont.)

Referee articles for: Physical Review, Physical Review Letters, Astrophysical Journals and Letters, Journal Mathematical Physics, Science.

Review Research Proposals for: N.A.S.A., N.S.F.

Relativity Proposal Review Panel for N.A.S.A. October 17, 1977.

Erice, Italy, Lecture at NATO Conference, May 1977.

Trieste, Italy, Conference on Relativity, July, 1975.

Pavia, Italy, Exp. Relativity Meeting, September, 1976.

Pakistan, Lecture UNESCO School, July, 1980.

MEETINGS ATTENDED AND PAPERS GIVEN

Relativity Proposal Review Panel for N.A.S.A., October 17, 1977.

Lecturer at the International School of Cosmology and Gravitation in Erice, Sicily in May, 1977.

NASA Symposium, April 1977, Steering Committee Experimental Relativity in Space. Two papers given: "Comments on the Solar Probe and Mercury Orbiter" and "Clock Experiments: Theoretical Significance."

International Meeting on Experimental Gravity, Pavia, Italy, Sept. 1976, "A Study of One and Two Way Doppler Tracking of a Clock on an Arrow Toward the Sun."

Smithsonian Astrophysical Observatory Seminar, December 1976, "Discussion of the SAO Solar Prob."

"Theoretical Significance of Lunar Laser Ranging," NATO Workshop on Exp. Relativity and Non-Quantum Demolition - August, 1981.

"Relativistic Tidal Forces," Salt Lake Rock Mountain Theory Meeting, March 23-27, 1982.

"Empirical Foundations of Gravitational Theory," colloquium, Purdue University, February 1986.

"Probing Gravity to 2nd Post Newtonian Order and to a Part in 10^7 Using the Space Axis of the Sun," Stockholm General Relativity and Gravity Meeting, July 1986.

"Probing Gravity to 2nd Post Newtonian Order and to a Part in 10^7 Using the Space Axis of the Sun," and "4 the Test of General Relativity Revisited," Laramie Rocky Mountain Theor. Physics, October 1986.

ADMINISTRATIVE ASSIGNMENTS

FPAC Personnel Sub-Committee	1970-1971
L&S Core Curriculum Committee	1973-1974
L&S Credibility Committee	1973-1974

COMMITTEE ASSIGNMENTS

Colloquium Committee	1967-1968
Department Advisory Committee	1969-1970
Graduate Committee	1971-1972
Exam Committee	1972-1974

AWARDS AND HONORS FOR TEACHING, SCHOLARSHIPS OR SERVICE

Harvard Society of Fellows	1963-1965
Visiting Professor (University of Colorado)	1967
Visiting Professor (Wesleyan University)	1969
Sloan Fellowship	1971-1973
Sigma Xi Research Award, MSU	1971
Visiting Professor (Princeton University)	1972
Visiting Professor (Smithsonian Astrophy. Observatory)	1975
Visiting Professor (Cal Tech)	1976
Wiley Research Award, MSU	1985

THESES DIRECTED

Student Name	Degree	Date
Dave Burdick	Ph.D.	1970
Ronald Hellings	Ph.D.	1973

PUBLIC SERVICE ACTIVITIES

Consultant to NASA on Gravity Experiments	1970-1975
Montana Legislature	1979-1984

RESEARCH CONTRACTS OR GRANTS DIRECTED

Agnecy	Title	Dates	Amounts
NASA	Space Navigation	1965-1966	$11,000
NASA	Space Navigation	1966-1967	11,000
NASA	Gravitation	1969-1970	22,000
NASA	Gravitation	1970-1971	24,000
NASA	Gravitation	1971-1972	34,000
NASA	Gravitation	1972-1973	30,000
NASA	Gravitation	1973-1974	30,000
NASA	Gravitation	1974-1975	20,000
NASA	Gravitation	1975-1976	16,000
NASA	Gravitation	1976-1977	16,000
NASA	Gravitation	1977-1978	16,000
MONTS	Relativistic Tidal forces	1983-1984	11,000
NSF	Relativistic Tidal Forces	1984-1986	56,916
NSF	Gravitation (submitted)	1987-1988	30,764
NSF	Gravitation (submitted)	1989-1992	18,490

RESEARCH PROJECT

Topic	Date
Observation Gravity and Cosmology	1967-present
Quantum Many-Body Problems	1965-1968-1974-present
Many Worlds Quantum Mechanics	1979-present

COURSES TAUGHT AT MSU

Modem Physics
Physics as a Natural Philosophy
Electromagnetic Theory
Nuclear Physics
General Relativity
Solid State Physics
Many Body Problems
Method of Math Physics
Classical Mechanics
Western Civilization (College Team)
Energy

Curriculum Vita

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PERSONAL

Birthdate: February 4, 1947
Social Security Number: 477-54-4425

EDUCATION

B.S.	Physics	1969	University of Minnesota
M.S.	Physics	1971	Harvard University
Ph.D.	Physics	1974	Harvard University

Major Research Interests

Non-linear Optics
Stimulated Raman Scattering
Solitons in Stimulated Raman Scattering
Quantum Fluctuations

Memberships in Professional Societies

American Physical Society
Optical Society of America
Division of Atomic, Molecular, and Optical Physics
American Association of Physics Teachers

PREVIOUS POSITIONS AND EXPERIENCE

1990 - Present	Professor	Physics Department, Montana State University, Bozeman, Montana
1984 - 1990	Associate Professor	Physics Department, Montana State University, Bozeman, Montana
1981 - 1984	Associate Group Leader	Los Alamos National Laboratory, Los Alamos, New Mexico
1979 - 1981	Staff Member	Los Alamos National Laboratory, Los Alamos, New Mexico
1976 - 1979	Assistant Professor	Physics Department, University of Colorado, Boulder, Colorado
1976 - 1979	Senior Research Assoc.	Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder, Colorado
1974 - 1976	Postdoc. Res. Assoc.	Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder, Colorado
1969 - 1974	Research Assistant	Physics Department, Harvard University, Cambridge, Massachusetts
1972	Teaching Assistant	Physics Department, Harvard University, Cambridge, Massachusetts
1966 - 1969	Research Assistant	Physics Department, University of Minnesota, Minneapolis, Minnesota

AWARDS

Outstanding Performance Award from Los Alamos National Laboratory (1980).

Phi Kappa Phi Fridley Distinguished Teaching Award at Montana State University (1986).

Wiley Award for Excellence in Research at Montana State University (1986).

Pi Sigma Alpha Mortar Board Award for Teaching at Montana State University (1986-1987).

Pi Sigma Alpha Mortar Board Award for Teaching at Montana State University (1987-1988).

Sigma Xi Outstanding Research Scientist Award at Montana State University (1989).

Outstanding Teaching Award in College of Letters and Science at Montana State University (1989).

Cox Excellence Award for Creative Scholarship and Teaching (1990).

REFEREED PUBLICATIONS

"Populating Excited States of Incoherent Atoms Using Coherent Light," T.J. McIlrath and J.L. Carlsten, Phys. Rev. A6, 109, (1972).

"Production of Large Numbers of Atoms in a Selected Excited State by Laser Optical Pumping: Calcium," T.J. McIlrath and J.L. Carlsten, J. Phys. B6, 697 (1973).

"Observations of Stimulated Anti-Stokes Radiation in Barium Vapor," J.L. Carlsten and T.J. McIlrath, J. Phys. B6, L80 (1973).

"An Oscillator-Amplifier Dye Laser: Tuneable High Powers without Grating Damage," J.L. Carlsten and T.J. McIlrath, Optics Com. 8, 52 (1973).

"Revised Absolute Absorption Cross-Section of Ba I at 237.9 nm," J.L. Carlsten and T.J. McIlrath, J. Phys. B6, L284 (1973).

"Measurement of the Photoionization Cross-Section from the Laser-Populated ^{3}D Metastable Levels in Barium," J.L. Carlsten, T.J. McIlrath, and W.H. Parkinson, J. Phys. B7, L244 (1974).

"Laser Selective Excitation of a Three-Level Atom: Barium," J.L. Carlsten, J. Phys, B8, 38 (1974).

"Absorption Spectrum of the Laser-Populated ^{3}D Metastable Levels in Barium," J.L. Carlsten, T.J. McIlrath and W.H. Parkinson, J. Phys. B8, 38 (1975).

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"Photoionization of Barium Clouds via the ^3D Metastable Levels," J.L. Carlsten, Plan. Space Sci., 23, 53 (1975).

"Stimulated Stokes Emission with a Dye Laser: Intense Tunable Radiation in the Infrared," J.L. Carlsten and P.C. Dunn, Optics Com. 14, 8 (1975).

"Binding of an Electron by the Field of a Molecular Dipole -- $LiCl^-$, J.L. Carlsten, J.R. Peterson, and W.C. Lineberger, Chem. Phys. Lett. 37, 5 (1976).

"Spectral Resolution of Near-Resonant Rayleigh Scattering and Collisionally-Induced Resonance Fluorescence," J.L. Carlsten and A. Szoke, Phys. Rev. Lett. 36, 667 (1976).

"Collisional Redistribution of Near-Resonant Scattered Light in Sr Vapor," J.L. Carlsten and A. Szoke, J. Phys. B9, L231 (1976).

"Near-Resonant Scattering and Collision-Induced Fluorescence," J.L. Carlsten and A. Szoke, Optics Communications, 18, 138 (1976).

"Collisional Redistribution and Saturation of Near-Resonant Scattered Light in Sr. Vapor," J.L. Carlsten, A. Szoke and M.G. Raymer, Optics Communications 18, 196 (1976).

"Spontaneous Raman Processes in Multi-photon Excitation of Sodium," P.B. Hogan, J.L. Carlsten, F.M.J. Pichanick, S.J. Smith, and W.W. Smith, Phys. Rev. Lett. 37, 990 (1976).

"Collisional Redistribution and Saturation of Near-Resonant Scattered Light," J.L. Carlsten, A. Szoke and M.G. Raymer, Phys. Rev. A15, 1029 (1976).

"Laser Spectroscopy III," J.L. Hall and J.L. Carlsten (Editors), Springer Series in Optical Sciences, Vol. 7, Springer-Verlag, Heidelberg (1977).

"Simultaneous Observations of Stimulated Collisional-Induced Fluorescence and Stimulated Raman Scattering," M.G. Raymer and J.L. Carlsten, Phys. Rev. Lett. 39, 1326 (1977).

"Stimulated Collision-Induced Fluorescence Observed," J.L. Carlsten and M.G. Raymer, Dimensions 62, 18 (1978).

"Self-broadening of the Tl 377.6 nm Resonance Line," G. Pichler and J.L. Carlsten, J. Phys. B11, L483 (1978).

"Theory of Stimulated Raman Scattering with Broadband Lasers," M.G. Raymer, J. Mostowski, and J.L. Carlsten, Phys. Rev. A19, 2304 (1979).

"Comparison of Collisional Redistribution and Emission Line Shapes," M.G. Raymer, J.L. Carlsten, and G. Pichler, J. Phys. B12, L119 (1979).

"Stimulated Rotational Raman Scattering in Para-H_2," J.L. Carlsten and R.G. Wenzel, IEEE J. Quant. Electron. QE-19, 1407 (1983).

"Observation of Solitons in Stimulated Raman Scattering," K.J. Druhl, R.G. Wenzel, and J.L. Carlsten, Phys. Rev. Lett. 51, 1171 (1983).

"Transient Effects and Pump Deletion in Stimulated Raman Scattering," J.L. Carlsten, R.D. Wenzel, and K.J. Druhl, SPIE 380, 201 (1983).

"Efficient Stimulated Raman Scattering Due to Absence of Second Stokes Growth," J.L. Carlsten, J.M. Telle, and R.G. Wenzel, Optics Letters, 9, 353 (1984).

"Induced Solitons in Stimulated Raman Scattering," R.G. Wenzel, K.J. Druhl, and J.L. Carlsten, JOSA B1, 445 (1984).

"Soliton Experiments in Stimulated Raman Scattering," R.G. Wenzel, J.L. Carlsten, and K.J. Druhl, Journal of Statistical Physics, 39, 621 (1985).

"Aspects of Soliton Propagation in Stimulated Raman Scattering," K.J. Druhl, J.L. Carlsten, and R.G. Wenzel, Journal of Statistical Physics, 39, 615 (1985).

"The Role of Transiency in the Formation of Solitons in Stimulated Raman Scattering," J.L. Carlsten and D.C. MacPherson, Optical Instabilities, Cambridge University Press, Cambridge, (1986) 337.

"Fresnel Diffraction in an Optical System Containing Lenses," R.G. Wenzel, J.M. Telle, and J.L. Carlsten, JOSA A3, 838 (1986).

"Spatial Mode Structure of Stimulated Stokes Emission from a Raman Generator," J.L. Carlsten, J. Rifkin, and D.C. MacPherson, JOSA B3, 1476 (1986).

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"Laser Speckle," J.L. Carlsten, The Physics Teacher, 25, 175 (1987).

"Gain Enhancement in an XeCl Pumped Raman Amplifier," J. Rifkin, M.L. Bernt, D.C. MacPherson and J.L. Carlsten, JOSA B 5, 1607 (1988).

"Competition Between Raman and Fluorescence Components in a Three-Level Amplifier," B.J. Herman, J.H. Eberly, M.G. Raymer and J.L. Carlsten, to be published.

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"Quantum Fluctuations in the Stimulated Raman Scattering Line Width," D.C. MacPherson, R.C. Swanson and J.L. Carlsten, Phys. Rev. Lett. 61, 66 (1988).

"Stimulated Raman Scattering in the Visible with a Multi-Pass Cell," D.C. MacPherson, R.C. Swanson and J.L. Carlsten, IEEE J. of Quant. Elect. 25, 1741 (1989).

"Soliton Initiation and Decay in Stimulated Raman Scattering," D.C. MacPherson, R.C. Swanson and J.L. Carlsten, Phys. Rev. A, Rapid Communication, 39, 6078 (1989).

"Quantum Fluctuations and Correlations in Stimulated Raman Scattering," D.C. MacPherson, R.C. Swanson, and J.L. Carlsten, Phys. Rev. A, 39, 3487 (1989).

"Spontaneous Solitons in Stimulated Raman Scattering," D.C. MacPherson, R.C. Swanson, and J.L. Carlsten, Phys. Rev. A, Rapid Communication, 40, 6745 (1989).

"Quantum Statistics of the Gain Narrowed Raman Linewidth in H_2," R.C. Swanson, P.R. Battle, and J.L. Carlsten, Phys. Rev. A, in press (1990).

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"Measurement of the Absolute Photoionization Cross-Section of Barium at 2̊37.9 nm," T.J. McIlrath and J.L. Carlsten, Bull. Am. Phys. Soc. 18, 1522 (1973).

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"Pressure Dependence of Collision-Induced Fluorescence," M.G. Raymer, J.L. Carlsten, and A. Szoke, Bull. Am. Phys. Soc. 21, 1246 (1976).

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"Radiative and Collisional Effects in Three Level Atoms," J.L. Carlsten and M.G. Raymer, Laser Spectroscopy III, Vol. 7 of Optical Science Series, Springer-Verlag, Heidelberg (1977) 204.

"Collisional Redistribution in Near-Resonant Rayman and Rayleigh Scattering," J.L. Carlsten and A. Szoke, in Abstracts from the International Conference on Multiphoton Processes (University of Rochester, 1977) 105.

"Collisional Redistribution of Stimulated Emission," M.G. Raymer and J.L. Carlsten, in Electronic and Atomic Collisions, Abstracts of Papers of the Xth ICPEAC (Commissariat a l'Energie Atomique, Paris) pg. 1284 (1977).

"Simultaneous Observations of Stimulated Raman Scattering and Stimulated Collision-Induced Fluorescence," M.G. Raymer and J.L. Carlsten, Bull. Am. Phys. Soc. 22, 1318 (1977).

"Gains for Stimulated Raman Scattering and Collision-Induced Fluorescence," M.G. Raymer and J.L. Carlsten, B.A.P.S. 23, 1106 (1978).

"Comparison of Collisional Redistribution and Emission Line Shapes," M.G. Raymer, J.L. Carlsten, and G. Pichler, B.A.P.S. 23, 1092 (1978).

"Soliton Evolution in Stimulated Raman Scattering," J.L. Carlsten, K.J. Druhl, and R.G. Wenzel, Optics News 9, 77 (1983).

"Solitons and Ultraviolet Pulse Compression in Stimulated Raman Scattering," J.L. Carlsten, K.J. Druhl, and R.G. Wenzel, Optics News 9, 77 (1983).

"High Repetition-Rate Raman Generation of Infra-Red Radiation," N.A. Kurnit, D.E. Watkins, G.W. York, and J.L. Carlsten, Laser Spectroscopy VI, Springer Series in Optical Sciences, Springer-Verlag, Heidelberg, (1983).

"Creation of Solitons in Stimulated Raman Scattering," J.L. Carlsten, K.J. Druhl, and R.G. Wenzel, Bull. Am. Phys. Soc. 29, 796 (1984).

"Efficient, High-Energy Ultraviolet Raman Generator," J.M. Telle, J.L. Carlsten, and R.G. Wenzel, Optics News, 10, 70 (1984).

"Solitons in Stimulated Raman Scattering," J.L. Carlsten, R.G. Wenzel, J.R. Ackerhalt, and K. Druhl, LASERS '84 proceedings, STS Press, (1985) 144.

"Angular Spectrum of the 88% Efficient Raman Generator," J.L. Carlsten and D.P. Ball, LASERS '84 proceedings, STS Press, (1985), 255.

PUBLISHED PROCEEDINGS AND ABSTRACTS (cont.)

"Solitons in Stimulated Raman Scattering," J.L. Carlsten, Bull. Am. Phys. Soc., 30, 877 (1985).

"Spatial Mode Structure of Stimulated Stokes Emission from a Raman Generator," J.L. Carlsten, J. Rifkin, and D.C. MacPherson, Advances in Laser Science -I, AIP Conference Proceedings No. 146. Ed. William C. Stwalley and Marshall Lapp, (1986) 316.

"Generation of Solitons in Transient Stimulated Raman Scattering by Optical Phase Shifts," D.C. MacPherson and J.L Carlsten, Advances in Laser Science -II, AIP Conference Proceedings No. 160. Ed. M. Lapp, W.C. Stwalley and G.A. Kenney-Wallace (1987) 220.

"Solitons in Stimluated Raman Scattering," J.L. Carlsten and D.C. MacPherson, Spectral Line Shapes, Vol. 4, Ed. R.J. Exton, Deepak publishing (1987) 523.

"Generation of Solitons in Transient Stimulated Raman Scattering by Optical Phase Shifts," D.C. MacPherson and J.L. Carlsten, Bull. Am. Phys. Soc., 32, 1268 (1987).

"Role of Transiency in the Gain Enhancement of a Raman Amplifier," J. Rifkin, M.L. Bernt, D.C. MacPherson, and J.L. Carlsten, SPIE, Vol. 874, 39-45 (1988).

"Statistics of Quantum Fluctuations in the Stimulated Raman Scattering Power Spectrum," D.C. MacPherson, R.C. Swanson and J.L. Carlsten, Bull. Am. Phys. Soc., 33 1012 (1988).

"Quantum Fluctuations in the Stimulated Raman Scattering Linewidth," D.C. MacPherson and J.L. Carlsten, Advances in Laser Science - III, AIP Conference Proceedings No. 172. Eds. A.C. Tam, J.L. Gole, and W.C. Stwalley, (1988), 204.

"Measurement of Quantum Fluctuations in the Single Shot Stokes Linewidth in Stimulated Raman Scattering," J.L. Carlsten, D.C. MacPherson, and R.C. Swanson, SPIE, 1060, 88-96 (1989).

"The Effects of Quantum Fluctuations on Soliton Amplitudes in Stimulated Raman Scattering," R.C. Swanson, D.C. MacPherson, and J.L. Carlsten, Bull. Am. Phys., 34, 1364 (1989).

"Effect of Quantum Fluctuations on the Spectrum of Stimulated Raman Scattering," J.L. Carlsten, D.C. MacPherson, and R.C. Swanson, Bull. Am. Phys. Soc., 34, 1689 (1989).

"Quantum Fluctuations in the Stimulated Raman Scattering Spectrum," R.C. Swanson, D.C. MacPherson, and J.L. Carlsten, Coherence and Quantum Optics VI, 1125 (1990).

INVITED PAPERS

"Experiments on Resonant Light Scattering in the Presence of Collisions," invited paper at the Resonant Light Scattering Symposium, Massachusetts Institute of Technology, Cambridge, Massachusetts, April 1976.

"Collisional Effects in Near-Resonant Scattering of Light," invited paper at the Division of Electron and Atomic Physics meeting of the American Physical Society, Lincoln, Nebraska, December 1976.

"Collisional and Radiative Effects in Three Level Atoms," invited paper at the Third International Conference of Laser Spectroscopy, Jackson, Wyoming, July 1977.

"Collisional Effects in Near-Resonant Scattering," invited paper at the Gordon Research Conference on Atomic and Molecular Interactions, Brewster Academy, Wolfeboro, New Hampshire, July 1978.

"Collisional Redistribution," invited paper at the Fourth International Conference on Spectral Line Shapes, Windsor, Canada, June 1978.

"Stimulated Raman Scattering and Four-Wave Mixing in CO_2-Pumped Para-H_2," invited paper at the Topical Meeting on Infrared Lasers, Los Angeles, California, December 1980 (with N.A. Kurnit).

"Observation of Soliton Evolution in Stimulated Raman Scattering," invited paper at the Gordon Research Conference on Nonlinear Optics and Lasers, Wolfeboro, New Hampshire, August 1983 (with K.J. Druhl and R.G. Wenzel).

"Induced Solitons in Stimulated Raman Scattering," Invited paper at XIII International Conference on Quantum Electronics, Anaheim, California, June 1984 (with R.G. Wenzel and K.J. Druhl).

"Observation of Solitons in Stimulated Raman Scattering," invited paper at Joint LANL-UNM workshop on Solitons in Stimulated Raman Scattering, Los Alamos, New Mexico, January 1984 (with R.G. Wenzel).

"Observation of Solitons in Stimulated Raman Scattering," invited paper at CNLS conference on "Transport and Propagation in Nonlinear Systems," Los Alamos, New Mexico, May 1984 (with R.G. Wenzel and K.J. Druhl).

"Aspects of Soliton Propagation in Stimulated Raman Scattering," invited paper at CNLS conference on "Transport and Propagation in Nonlinear Systems," Los Alamos, New Mexico, May 1984 (with K.J. Druhl and R.G. Wenzel.)

"Solitons in Stimulated Raman Scattering," invited paper at Lasers '84 Conference, San Francisco, California, November 1984 (with R.G. Wenzel, J.R. Ackerhalt, and K.J. Druhl).

INVITED PAPERS (cont.)

"Solitons in Stimulated Raman Scattering," invited paper at the Annual Meeting of the Division of Electron and Atomic Physics of the American Physical Society, Norman, Oklahoma, May 1985.

"The Role of Transiency in the Formation of Solitons in Stimulated Raman Scattering," invited paper at the International Meeting on Instabilities and Dynamics of Lasers and Nonlinear Optical Systems, Rochester, New York, June 1985 (with D.C. MacPherson).

"Solitons in Stimulated Raman Scattering," invited paper at the 8th International Conference on Spectral Line Shapes, Williamsburg, Virginia, June 1986.

"Nonlinear Optics," invited paper at the Montana Section of the American Association of Physics Teachers, Bozeman, Montana, October 1986.

"Introduction to Nonlinear Optics," invited paper at the AAPT National Meeting, Bozeman, Montana, June, 1987.

"Nonlinear Optics," invited paper at the PTRA meeting - Frontiers of Physics, Bozeman, Montana, July, 1987.

"Role of Transiency in the Gain Enhancement of a Raman Amplifier," invited paper at the SPIE symposium on Lasers and Optics, Los Angeles, California, January 1988.

"Quantum Fluctuations and Soliton Formation in Stimulated Raman Scattering," invited paper at the Annual meeting of the Optical Society of America, Santa Clara, California, October, 1988 (presented by D.C. MacPherson).

"Solitons in Multiphoton Interactions," organized symposium at the Annual meeting of the Optical Society of America, Santa Clara, California, October, 1988.

"Measurement of Quantum Fluctuations in the Single Shot Stokes Linewidth in Stimulated Raman Scattering," invited paper at the SPIE OE/LASE '87 meeting in Los Angeles, California, January, 1989.

"Quantum Fluctuations in Stimulated Raman Scattering," invited paper at the LLNL Raman Modeling Workshop in Livermore, California, February, 1989.

"Effects of Quantum Fluctuations on the Spectrum of Stimulated Raman Scattering," invited paper at ILS-V at Stanford, California, August, 1989.

"Effects of Quantum Fluctuations on Raman Soliton Formation," invited paper at the Nonlinear Optics Conference, Kquai, Hawaii, July, 1990.

CONTRIBUTED PAPERS

"Stimulated Anti-Stokes Radiation in Barium Vapor," presented at the New England Section of the Division of Electron and Atomic Physics of the American Physical Society, Hartford, Connecticut, April 1973.

"Measurement of the Photoionization Cross-Section from the Laser Populated ^3D Metastable in Barium," presented at the VIII International Conference on the Physics of Electron and Atomic Collisions, Belgrade, Yugoslavia, July 1973.

"Photoionization Spectroscopy from the Laser-Populated ^3D Metastable in Barium," presented at the Division of Electron and Atomic Physics meeting of the American Physical Society, New Haven, Connecticut, December 1973.

"Binding of an Electron by the Field of a Molecular Dipole -- $LiCl^-$," presented at the IX International Conference on the Physics of Electron and Atomic Collisions, Seattle, Washington, July 1975.

"Near-Resonant Rayleigh Scattering and Collision Induced Fluorescence," International Conference on Quantum Electronics, Amsterdam, The Netherlands, June 1976.

"Collisional Redistribution and Saturation of Near-Resonant Scattered Light in Sr Vapor," IX International Conference on Quantum Electronics, Amsterdam, The Netherlands, June 1976.

"Theory of Stimulated Raman Scattering with Broadband Lines," contributed paper at the Los Alamos Conference on Optics '79, Los Alamos National Laboratory, Los Alamos, New Mexico, May 1979 (with M.G. Raymer).

"Raman Amplification in CO_2 Pumped Para-H_2," contributed to the XI International Quantum Electronics Conference, Boston, Massachusetts, June 1980 (with N.A. Kurnit).

"Transient Effects and Pump Depletion in Stimulated Raman Scattering," contributed to the Los Alamos Conference in Optics, Santa Fe, New Mexico, April 1983 (with R.G. Wenzel and K.J. Druhl).

"Soliton Formation in Stimulated Raman Scattering," contributed to the Annual Meeting of OSA, New Orleans, Louisiana, October 1983 (with K.J. Druhl and R.G. Wenzel).

"Solitons and UV Pulse Compression in Stimulated Raman Scattering," contributed to the Annual Meeting of OSA, New Orleans, Louisiana, October 1983 (with K.J. Druhl and R.G. Wenzel).

"High Repetition-Rate Raman Generation of Infra-Red Radiation," contributed paper at the Sixth International Conference on Laser Spectroscopy, Interlaken, Switzerland, June 1983 (with N.A. Kurnit, D.W. Watkins, and G.W. York).

CONTRIBUTED PAPERS (cont.)

"Creation of Solitons in Stimulated Raman Scattering," contributed paper at the Annual Meeting of the Division of Electron and Atomic Physics of the American Physical Society, Storrs, Connecticut, May/June 1984 (with K.J. Druhl and R.G. Wenzel).

"Efficient High-Energy Ultraviolet Raman Generator," contributed paper at the Optical Society of America Annual Meeting, San Diego, California, November 1984 (with J.M. Telle and R.G. Wenzel).

"Angular Spectrum of the 88% Efficient Raman Generator," postdeadline paper at LASERS '84 Conference, San Francisco, California, November 1984 (with D.P. Ball).

"Spatial Mode Structure in Stimulated Raman Scattering," contributed paper at the First International Laser Science Conference, Dallas, Texas, November 1985 (with J. Rifkin).

"Generation of Solitons in Transient Stimulated Raman Scattering by Optical Phase Shifts," contributed paper at the Second International Laser Science Conference, Seattle, Washington, October 1986 (with D.C. MacPherson).

"Gain Enhancement in a XeCl Pumped Raman Amplifier," contributed paper at the XV International Conference on Quantum Electronics, Baltimore, Maryland, April 1987 (with J. Rifkin, M.L. Bemt and D.C. MacPherson).

"Generation of Solitons in Transient Stimulated Raman Scattering by Optical Phase Shifts," contributed paper at the XV International Conference on Quantum Electronics, Baltimore, Maryland, April 1987 (with D.C. MacPherson).

"Generation of Solitons in Transient Stimulated Raman Scattering by Optical Phase Shifts," contributed paper at the Division of Atomic, Molecular and Optical Physics Meeting of the American Physical Society, Cambridge, Massachusetts, May 1987 (with D.C. MacPherson).

"Quantum Fluctuations in the Stimulated Raman Scattering Linewidth," contributed paper at the Third International Laser Science Conference, Atlantic City, New Jersey, November 1987 (with D.C. MacPherson).

"Statistics of Quantum Fluctuations in the Stimulated Raman Scattering Power Spectrum," contributed paper at the Annual meeting of the Division of Atomic, Molecular and Optical Physics, Baltimore, Maryland, April, 1988 (with D.C. MacPherson and R.C. Swanson).

"Quantum Initiation of Stimulated Raman Scattering," contributed paper at the Annual meeting of the Optical Society, Santa Clara, California, October, 1988 (with D.C. MacPherson and R.C. Swanson).

"The Effects of Quantum Fluctuations in Soliton Amplitudes in Stimulated Raman Scattering," contributed paper at the annual meeting of the Division of Atomic, Molecular, and Optical Physics, Winsor, Ontario, May, 1989 (with R.C. Swanson and D.C. MacPherson).

CONTRIBUTED PAPERS (cont.)

"Quantum Fluctuations in the Stimulated Raman Scattering Spectrum," contributed paper at the Sixth Rochester Conference on Coherence and Quantum Optics, Rochester, New York, June, 1989 (with R.C. Swanson and D.C. MacPherson).

"Quantum Statistics of the Raman Generator Linewidth," contributed paper at the XVII International Quantum Electronics Conference, Anaheim, California, May, 1990 (with R.C. Swanson and P.R. Battle).

"A Cyclic Shearing Interferometer for Collimating Beams with Short Coherence Times," contributed paper at the Annual Meeting of the Optical Society of America, Boston, Massachusetts, November, 1990 (with T.D. Henning).

"Raman Amplifiers in a Two-Leg Interferometer: Quantum Noise vs. Fringe Visibility," contributed paper at the Annual Meeting of the Optical Society of America, Boston, Massachusetts, November, 1990 (with R.C. Swanson and P.R. Battle).

COLLOQUIA AND SEMINARS

"Spectroscopy of Laser-Populated Excited States: Preliminary Results in Barium," presented to the Division of Atomic and Molecular Physics at the Center for Astrophysics, Cambridge, Massachusetts, August 1973.

"Selective Excitation with Tuneable Dye Lasers," presented to the Physics Department of the University of New Hampshire, Durham, New Hampshire, April 1974.

"Selective Excitation with Tuneable Dye Lasers," presented to the Physics Department at Harvard University, Cambridge, Massachusetts, April 1974.

"Laser Selective Excitation: Excited State Studies of Vapors," MPSE Divisional Seminar on Quantum Electronics, University of Maryland, College Park, Maryland, December 1974.

"Spectroscopy of Laser Produced Excited States," presented at the National Bureau of Standards, Gaithersburg, Maryland, December 1974.

"Determining Excited State Photoionization Cross-Sections using Laser Selective Excitation," presented at the IBM Thomas J. Watson Research Center, Yorktown Heights, New York, December 1974.

"Binding of an Electron by a Dipole Field-$LiCl^-$ and $NaCl^-$," presented to the Division of Atomic and Molecular Physics at the Center for Astrophysics, Harvard University, Cambridge, Massachusetts, December 1974.

"Radiative Collisions: a) Basic Theory, b) Possible Experiments," presented at the Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder, Colorado, February 1975.

"Radiative Collisions," presented to the Physics Department at Imperial College of Science and Technology, London, England, July 1975.
"Radiative Collisions," presented to the Division of Atomic and Molecular Physics at the Center for Astrophysics, Harvard University, Cambridge, Massachusetts, July 1975.

"Near-Resonant Light Scattering on Strontium," presented at the Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder, Colorado, November 1975.

"Near-Resonant Scattering of Light," presented to the Division of Atomic and Molecular Physics at the Center for Astrophysics, Harvard University, Cambridge, Massachusetts, March 1976.

"Near-Resonant Scattering of Light," presented to the Physics Department at the University of New Hampshire, Durham, New Hampshire, March 1976.

"Resonant Light Scattering in the Presence of Collisions," Optical Physics Division Colloquium, National Bureau of Standards, Gaithersburg, Maryland, May 1976.

"Near-Resonant Light Scattering in Strontium Vapor," Colloquium to L-7 Group at Los Alamos Scientific Laboratory, Los Alamos, New Mexico, May 1976.

"Near-Resonant Light Scattering from Atoms in the Presence of Collisions," Colloquium at Stanford Research Institute, Menlo Park, California, May 1976.

"Collisional Redistribution in Near-Resonant Rayleigh and Raman Scattering," Physics Department Colloquium, University of Minnesota, Minneapolis, Minnesota, April 1977.

"Laser Scattering in the Presence of Collisions," Department of Physics Seminar at the University of Southern California, November 1977.

"Collisional Effects in Near-Resonant Scattering of Laser Light," Physics Department Colloquium, University of Connecticut, Storrs, Connecticut, April 1978.

"Forward-Backward Asymmetry in Stimulated Raman Scattering," Colloquium to AP-2 Group at Los Alamos Scientific Laboratory, Los Alamos, New Mexico, May 1978.

"Stimulated Raman Scattering," Physics Department Colloquium at Montana State University, Bozeman, Montana, March 1984.

COLLOQUIA AND SEMINARS (cont.)

"Solitons in Stimulated Raman Scattering," Laser Interaction Seminar, Montana State University, Bozeman, Montana, January 1985.

"Solitons in Stimulated Raman Scattering," colloquium at Stanford Research Institute, Menlo Park, California, July, 1985.

"Angular Distributions in Stimulated Raman Scattering," colloquium at Lawrence LivermoreLaboratory, Livermore, California, July, 1985.

"Spatial Mode Structure of Stimulated Stokes Emission from a Raman Generator," colloquium at Los Alamos National Laboratory, Los Alamos, New Mexico, December 1985.

"Spatial Mode Structure of Amplified Spontaneous Raman Emission," colloquium at Lawrence Livermore National Laboratory, Livermore, California, January, 1986.

"Research vs Teaching", panel discussion on program "Wait 'Till You Here This," on Montana State University public television, April, 1987.

"Stimulated Raman Scattering, Solitons and Quantum Fluctuations," colloquium at the University of Iowa, Iowa City, Iowa, April, 1989.

RESEARCH CONTRACTS OR GRANTS DIRECTED AT MSU

"Spatial Mode Structure of Amplified Spontaneous Raman Emission," Lawrence Livermore National Laboratory, $59,102 (1985), $57,283 (1986).

"Raman Amplifier Research Program," Los Alamos National Laboratory, $63,329 (1985), $60,895 (1986).

"Beam Combining of Eximer Lasers by Stimulated Raman Scattering," Office of Naval Research, $79,982 (1985-1986), $79,984 (1986), $54,000 (1987), $26,000 (1988).

"Experimental Studies of Soliton Formation in Stimulated Raman Scattering," National Science Foundation, $64,336 (1986-1987), $59,920 (1987-1988), $67,457 (1988-1989), REU supplement, $2,300 (1988).

"A Laser Based Study of Molecular Beam Epitaxy Growth Kinetics," (with W.K. Ford), MONTS, $9,000 (1987-88).

"Experimental Studies of Soliton Formation and Quantum Fluctuations in Stimulated Raman Scattering," National Science Foundation, $70,634 (1989-1990), $78,430 (1990-1991).

RESEARCH CONTRACTS OR GRANTS DIRECTED AT MSU (cont.)

"Two Photon Photoelectron Spectroscopy of III-V Semiconductors," (with W.K. Ford) Montana Science and Technology Alliance, $29,784 (1989).

"Experimental Studies of Aperture Diffraction of Spherical Waves," Idaho National Engineering Laboratory, $19,525 (1990).

"Studies of Spatial Mode Structure from a Generator-Amplifier System," Lawrence Livermore National Laboratory, $46,611 (1990).

Resume

RUFUS L. CONE

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PERSONAL: Birthdate: April 28, 1944
Social Security Number: 257-66-9037

EDUCATION: B.S., Physics, 1962-1966, Georgia Institute of Technology
M.S., Physics, 1966-1967, Georgia Institute of Technology
Master of Philosophy, Physics, 1967-1968, Yale University
Ph.D., Physics, 1967-1971, Yale University, Werner P. Wolf, Advisor, Professor of Physics and Applied Science)

POSITIONS AND EXPERIENCE

1986 - Visiting Professor, Laboratoire de Spectrometrie Physique, Universite Grenoble
1984 to present - Professor, Montana State University
1983 - Science and Engineering Research Council Fellow at Clarendon Laboratory, University of Oxford, Oxford, UK, (March-June)
1982 - Visiting position at Bell Laboratories, Murray Hill, NJ (September-December), Consultant in Coherent Laser Spectroscopy.
1980 - Visiting position at Bell Laboratories, Murray Hill, NJ (March-June), Consultant in Coherent Laser Spectroscopy
1977 to 1982 - Associate Professor, Montana State University
1974 to 1977 - Assistant Professor, Montana State University
1971 to 1974 - Assistant Professor, University of Georgia
1968 to 1971 - Research Assistant, Yale University

CURRENT PROJECTS 1989

1) Studies of ion-ion interactions, energy localization-delocalization phenomena for optical excitons, relaxation processes, and structural effects in solids via nonlinear optics and laser spectroscopy (MSU, AT&T Bell Labs -- Murray Hill, Clarendon Laboratory -- Oxford, IBM Almaden Research Center, U. de Lyon, U. de Grenoble, U. of Manchester)
   a) Photon echo decay and photon echo modulation with pulsed lasers
   b) Phase-switched and frequency-switched optical coherent transients with cw laser
   c) Hole burning spectroscopy and optically-detected rf nuclear resonance
   d) Multiphoton absorption spectroscopy and UV laser spectroscopy
   e) Four-wave nonlinear optical mixing spectroscopy
   f) Transient resonant Raman spectroscopy and fluorescence line narrowing in biological systems.

2) Study of defects in PZT ferroelectric materials for microelectronic applications.

3) Theoretical analysis of high-lying energy levels and excited electronic configurations in rare earth ions in conjunction with experiments.

PUBLICATIONS:

1. "Optical Studies of Electric and Magnetic Interactions in Magnetic Rare Earth Insulators," R.L. Cone, Univ. Microfilm #71-28151, 1971. (Thesis, Yale University).

2. "Optical Studies of Energy Levels in $Eu(OH)_3$," R.L. Cone and R.L. Faulhaber, J. Chem. Phys. 55, 5198-5206 (1971).

3. "Energy Levels of Er^{3+} in Three Rare Earth Hydroxides," R.L. Cone, J. Chem. Phys. 57, 4893-4903 (1972).

4. "Anisotropic Exchange Effects in the Optical Spectrum of Ferromagnetic Er^{3+}:$Tb(OH)_3$," R.L. Cone and W.P. Wolf, in Magnetism and Magnetic Materials-1972, AIP Conference Proceedings No. 10, Ed. by C.D. Graham and J.J. Rhyne, pp. 1039-1043, (AIP, New York, 1973).

5. "Anisotropic Exchange Effects in the Exciton Spectrum of $GdCl_3$ and $Gd(OH)_3$," R.L. Cone and R.S. Meltzer, Phys. Rev. Letters 30, 859-863 (1973).

5a. Made major contribution to related paper:
"Electron Paramagnetic Resonance of Gd^{3+} Pairs in Rare Earth Hydroxides," R.W. Cochrane, C.Y. Wu., W.P. Wolf, Phys. Rev.B8, 4348 (1973).

6. "A Spherical Tensor Operator Description of the Exchange Splittings of Gd^{3+} in $GdCl_3$," R.S. Meltzer and R.L. Cone, in Magnetism and Magnetic Materials-1973, AIP Conference Proceedings, No. 18, Ed. By C.D. Graham and J.J. Rhyne, pp. 545-549, (AIP, New York, 1974).

7. "Energy Transfer Mechanisms in $Tb(OH)_3$ From Line Shapes of Band-to-Band Fluorescence," R.L. Cone and R.S. Meltzer, J. Chem. Phys. 62, 3573-81 (1975).

8. "Observation of Virtual Phonon Exchange in a Magnon-Like Exciton of $Tb(OH)_3$," R.L. Cone and R.S. Meltzer, in Magnetism and Magnetic Materials-1974, AIP Conference Proceedings No. 24, Ed. by C.D. Graham, G.H. Lander, and J.J. Rhyne, pp. 233-234, (AIP, New York, 1975).

9. "A Systematic Study of the Orbitally-Dependent Rare Earth Gd^{3+} Exchange Parameters in $GdCl_3$," R.S. Meltzer, R.L. Cone and D.K. Braswell, in Magnetism and Magnetic Materials-1974, AIP Conference Proceedings No. 24, Ed. by C.D. Graham, G.H. Lander, and J.J. Rhyne, pp. 211-212, (AIP, New York, 1975).

10. "A Repetitively Pulsed, High Power, N_2 Laser for Optically Pumping a Dye Laser System," K.T. Kilty, R.D. Nelson, and R.L. Cone, Proc. Mont. Acad. of Sci. 35 67-72 (1975).

11. "Fundamental Two-Electron Tensor Operator Description of the $Gd^{3+}4f^7$ Configuration Exchange Splittings in $GdCl_3$," R.S. Meltzer and R.L. Cone, Phys. Rev. B13, 2818-2830 (1976).

12. "Static and Dynamic Properties of Excitons in the Ferromagnet $Tb(OH)_3$," R.S. Meltzer and R.L. Cone. J. Lumin. 12 247-51 (1976).

PUBLICATIONS (continued)

13. "Anisotropic Exchange Effects in Optical Spectra: Er^{3+} in Ferromagnetic $Tb(OH)_3$," R.L. Cone and W.P. Wolf. Phys. Rev. B17 4162-80 (1978).

14. "The Potential for Combustion Gas Diagnostics Employing Nonlinear Laser Spectroscopy," D.A. Ender, R.D. Nelson, and R.L. Cone, Proc. Mont. Acad. Sci. 38, 120-126 (1979).

15. "Laser Anemometer Measurement of the Velocity of Water at Laminar Flow Rates Through a Glass Channel," J.F. Sullivan, William Genneti, and R.L. Cone, Proc. Mont. Acad. Sci. 38, 141-147 (1979).

16. "Ligation and Quaternary Structure Induced Changes in the Hemepocket of Hemoglobin: A Transient Resonance Raman Study," J.M. Friedman, R.A. Stepnoski, M. Stavola, M.R. Ondrias, and R.L. Cone, Biochemistry 21, 2022-2028 (1982).

17. "An LSI 11/2 Microcomputer Based Data Acquisition System for Laser Spectroscopy," P.L. Fisher and R.L. Cone, Rev. Sci. Instrum. 53, 634-636 (1982).

18. "Multiresonant Two-Photon-Absorption-Induced Four Wave Mixing in Crystal line Rare Earth Insulators," R.L. Cone, D.A. Ender, M.S. Otteson, P.L. Fisher, J.M. Friedman, and H.J. Guggenheim, in Laser Techniques for Extreme Ultraviolet Spectroscopy, AIP Conference Proceedings, No. 90, Ed. by T.J. McIlrath and R.R. Freeman, pp. 471-477 (AIP, New York, 1982).

19. "Multiresonant Two-Photon-Absorption-Induced Four Wave Mixing in Crystalline Rare Earth Insulators," R.L. Cone, D.A. Ender, M.S. Otteson, Paula L.Fisher, J.M. Friedman, and H.J. Guggenheim, Applied Physics B28, 143 (1982).

20. "Narrowed Intermediate State Resonances in Doubly-Resonant, Two-Photon-Absorption-Induced Four Wave Mixing in $LiTbF_4$," D.A. Ender, M.S. Otteson, R.L. Cone, M.B. Ritter, and H.J. Guggenheim, Optics Letters 7, 611-613 (1982).

21. "Nuclear Quadrupole Optical Hole Burning in Stoichiometric $EuVO_4$," R.L. Cone, R.T. Harley and M.J.M. Leask, J. Phys. C17 3101-3111 (1984).

22. "Exciton Dynamics Following Two Photon Absorption In $GdCl_3$," R. Mahiou, B. Jacquier, and R.L. Cone, J. Phys (Paris) 46, C7-119--C7-123 (1985).

23. "Effect of Magnetic Order on the Fluorescence Dynamics of TbF_3," M.F. Joubert, B. Jacquier, and R.L. Cone, Physical Review B 35, 8322-8329 (1987).

24. INVITED REVIEW ARTICLE: "Ion-Ion Interactions and Exciton Effects in Rare Earth Insulators," R.L. Cone and R.S. Meltzer, Chapter 8 (pp. 481-556, 76 pages) in Spectroscopy of Crystals Containing Rare-Earth Ions, (North Holland, 1987).

25. "Photon Echo Relaxation and Hole Burning in Tb^{3+}:$LiYF_4$ and $LiTbF_4$," G.K. Liu, M.F. Joubert, R.L. Cone, and B. Jacquier, J. Luminescence 38, 34-36 (1987).

PUBLICATIONS (continued)

26. "Direct Two-Photon Absorption of $Gd(OH)_3$ and $GdCl_3$ in an Applied Magnetic Field," B. Jacquier, Y. Salem, C. Linares, J.C. Gacon, and R.L. Cone, J. Luminescence 38, 258-260 (1987).

27. "Direct Two-Photon Excitation in Some Tb^{3+} Compounds," B. Jacquier, J.C. Gacon, J.F. Marcerou, M.F. Joubert, and R.L. Cone, J. Luminescence 40-41, 517-518 (1988).

28. "Photon Echo Relaxation and Hole Burning in Tb^{3+}:$LiYF_4$ and $LiTbF_4$," G.K. Liu, M.F. Joubert, R.L. Cone, and B. Jacquier, J. Luminescence 40-41, 551-552 (1988).

29. "Nuclear Quadrupole Optical Hole Burning in Stoichiometric $EuAsO_4$," M.J.M. Leask, M.G. Robinson, and R.L. Cone, J. Phys. C. 21, 3361-3380 (1988).

30. "Spectral Hole Burning, Zeeman Effect, and Hyperfine Structure for Tb^{3+}:$LiYF_4$," G.K. Liu, J. Huang, R.L. Cone, and B. Jacquier, Phys. Rev. B 38, 11061-11067 (1988).

31. "The Hyperfine Splitting of Holmium near an Energy Crossover in Yttrium Ethylsulphate," C. Carboni, R.L. Cone, Z-P. Han, and M.A.H. Mcausland, To appear in J. Phys. (Paris) 49, C8-843 to C8-844 (1988).

32. "Line Narrowing and Site Selectivity in Tryptophan Fluorescence from Proteins and Glasses: Cryogenic Studies of Conformational Disorder and Dynamics," T.W. Scott, B.F. Cambell, R.L. Cone, and J.M. Friedman, Chem. Phys. 131, 63-79 (1989).

33. "Resonant Enhancement of Direct Two-Photon Absorption in Tb^{3+}:$LiYF_4$," J. Huang, L. Guokui, and R.L. Cone, Phys. Rev. B 39, 6348-6354 (1989).

34. "Spectroscopic Analysis of Nd^{3+}-Nd^{3+} Pairs in $CsCdBr_3$," R.B. Barthem, R. Buisson, and R.L. Cone, J. Chem. Phys. 91, 627-632 (1989).

35. "Analysis of $^8S_{7/2}$ to $^6P_{7/2}$ Two-Photon Transitions of Gd^{3+} in $Gd(OH)_3$ in Applied Magnetic Field," J. Phys. Condensed Matter 1, 7385-7394 (1989).

36 "Fluorescence Measurements of the Exciton Dispersion in $Gd(OH)_3$," Y. Salem, B. Jacquier, and R.L. Cone, Accepted by Phys. Rev. B1, November, 1989.

37. "Energy Transfer and Instantaneous Spectral Diffusion Processes in Tb^{3+} Compounds as Probed in Photon Echo Experiments," G.K. Liu, R.L. Cone, M.F. Joubert, B. Jacquier, and J.L. Skinner, Accepted by J. Lumin., September, 1989.

38. "Laser-Induced Instantaneous Diffusion in Tb^{3+} Compounds as Observed in Photon Echo Experiments," G.K. Liu and R.L. Cone, Accepted by Phys. Rev. B1.

39. "Resonant Four-Wave Nonlinear Optical Mixing: Narrowed Single Photon Resonances in $Tb(OH)_3$ and $LiTbF_4$," D.A. Ender, M.S. Otteson, R.L.Cone, J.M. Friedman, and H.J. Guggenheim, Ready for submission to Phys. Rev. B.

PUBLICATIONS (cont.)

40. "Two-Photon-Resonant Four-Wave Mixing in $LiTbF_4$," Huang Jin, R.L. Cone, J.M. Friedman, H.J. Guggenheim, and B. Jacquier, Ready for submission to Phys. Rev.

41. "Nondegenerate Four-Wave Mixing in TbF_3," J. Huang, R.L. Cone, and B. Jacquier, Ready for submission to Applied Physics Letters.

42. "Nuclear Shielding Factors for Ho^{3+} in $LaCl_3$, $Y(OH)_3$, and Yttrium Ethyl Sulphate," M.A.H. McCausland, C. Carboni, and R.L. Cone, to be submitted to J. Phys. C.

43. "Optical Coherent Transient and Hole Burning Studies of the $^7F_0$-$^5D_0$ Transition in $Eu(OH)_3$," M.S. Otteson, R.L. Cone, R.M. Macfarlane, and R.M. Shelby, to be submitted to Physical Review.

44. "Quasi-Resonant Optical Energy Transfer and Excited State Dynamics in $LiTbF_4$ Probed via Photon Echoes--Localized and Delocalized States?," G.K. Liu, R.L. Cone, M.F. Joubert, J.L. Skinner, and B. Jacquier, to be submitted to Phys. Rev.

45. "Tb^{3+}--F^- Transferred Hyperfine Structure for Tb^{3+}:$LiYF_4$ via Photon Echo Modulation Spectroscopy" G.K. Liu and R.L. Cone, to be submitted to Phys. Rev.

46. "Resonant Four-Wave Mixing in $ErPO_4$," J. Huang, R.L. Cone, P.C. Becker, N. Edelstein, L.A. Boatner, and M.M. Abraham, to be submitted to J. Chem. Phys.

47. "Programmable Nanosecond Laser Delay Generator," D.W. Jones, A. Beldring, and R.L. Cone, to be submitted to Review of Scientific Instruments.

48. "Polarization Sensitive Spectral Response of an Optical Double Monochromator with Holographic Gratings," R. Jones, J. Eggert, M. J. Kimlinger and R.L. Cone, to be submitted to Review of Scientific Instruments.

49. "A Laser Trigger Module for N_2 Lasers and Excimer Lasers with Less Than One Nanosecond Jitter," A. Beldring, Huang Jin, and R.L. Cone, to be submitted to Review of Scientific Instruments.

PAPERS BEING WRITTEN (work completed)

"Static Photon Echo Discrimination Technique Applicable to Picosecond Photon Echo Measurements," R.L. Cone, G.K. Liu, and P.F. Darejeh.

"Electro-optic Phase Modulation for Phase Switched Coherent Optical Transients and FM Spectroscopy: Sources of Noise and Spurious Amplitude Modulation," R.L. Cone and M.S. Otteson.

"Crystal Field Analyses of $Tb(OH)_3$, Tb^{3+}:$Y(OH)_3$, and Tb^{3+}:$LaCl_3$," G.K. Liu and R.L. Cone, to be submitted to Phys. Rev.

"Excited State Absorption Spectra of Tb^{3+} from the $^5D_4$ Manifold to 46,000 cm^{-1} in 1% $LiYF_4$," R.L. Cone, G.K. Liu, T.W. Scott, J.M. Friedman, H.J. Guggenheim, and H. Crosswhite, to be submitted to Physical Review.

"Observation of UV Fluorescence in Tb^{3+}:$LiYF_4$ and $LiTbF_4$," R.L. Cone, T.W. Scott, J.M. Friedman, and H.J. Guggenheim, to be submitted to Applied Physics Letters.

"Ultraviolet Absorption, Fluorescence, and Resonance Raman Scattering from Parity-allowed Transitions of Tb^{3+} in $LiTbF_4$, 1% Tb^{3+}:$LiYF_4$, and $Tb(OH)_3$," R.L. Cone, T.W. Scott, J.M. Friedman, and H.J. Guggenheim, to be submitted to Physical Review.

"Active Raman Line Narrowing of Inhomogeneously Broadened Vibrations in GeO_2 Glass," T.W. Scott, R.L. Cone, and J.M. Friedman, to be submitted to Phys. Rev.

"Saturation of Excitation Density and Novel Exciton Annihilation Dynamics in $LiTbF_4$ and $Tb(OH)_3$," D.A. Ender, M.S. Otteson, R.L. Cone, J.M. Friedman, and H.J. Guggenheim, to be submitted to Phys. Rev.

"Biquadratic Exchange Between Gd^{3+} Pairs from Anisotropic Bilinear Exchange," R.L. Cone and W.P. Wolf, to be submitted to Physical Review.

"Optical Energy Transfer Via the Electronic Exchange Interaction in Eu^{2+} and Gd^{3+} Compounds," R.L. Cone, to be submitted to Phys. Rev.

"A Systematic Study of the Orbitally-Dependent Anisotropic Exchange Parameters in $GdCl_3$ Doped with Nd^{3+}, Ho^{3+}, and Er^{3+}," R.L. Cone and R.S. Meltzer, to be submitted to Phys. Rev.

"Systematics of Phonon Raman Spectra in the Rare Earth Hydroxides," M.S. Otteson, D.A. Ender, R.L. Cone, and S. Mrosczkowski, to be submitted to Physical Review.

"A Simple Adjustable Optical Attenuator for Photodiode Laser Pulse Energy Measurements," Huang Jin, W.A. Tolbert, and R.L. Cone, to be submitted to Applied Optics.

"Optical Cryogenic Insert Dewar for Superconducting Magnet Applications," R.L. Cone, D.A. Ender, and D.W. Jones, to be submitted to Rev. Sci. Instr.

"Optical Dephasing in Solids Via Two-Photon-Resonant Four-Wave Mixing with

PAPERS BEING WRITTEN (work completed) (continued)

Intermediate State Resonances," R.L. Cone and J.M. Friedman, to be submitted to Physical Review.

"Phase Matching in Multiresonant Four-Wave Nonlinear Optical Mixing," M.S. Otteson, D.A. Ender, Huang Jin, R.L. Cone, and J.M. Friedman, to be submitted to Physical Review.

CONFERENCE PAPERS, SEMINARS, AND COLLOQUIA

14th Annual Conference on Magnetism and Magnetic Materials - Nov. 18-21, 1968, NY.

1969 Annual Meeting of APS, Feb. 3-6, 1969, New York.

1971 Annual Meeting of APS, Feb. 1-4, 1971, New York.

18th Annual Conference on Magnetism and Magnetic Materials - Nov. 28--Dec. 1, 1972, Denver. Anisotropic Exchange Effects in the Optical Spectrum of Ferromagnetic Er^{3+}: $Tb(OH)_3$, R.L. Cone and W.P. Wolf.

1973 Annual Meeting of APS, Jan. 29--Feb. 1, 1973, NY. Anisotropic Exchange Effects in the Exciton-Magnon Spectrum of $GdCl_3$ and $Gd(OH)_3$, R.L. Cone and R.S. Meltzer.

Southeastern Section Meeting of APS, Nov. 8-10, 1973, Winston Salem, NC. Biquadratic Exchange Between Gd^{3+} Pairs Arising from Anisotropic Bilinear Exchange, R.L. Cone.

19th Annual Conference on Magnetism and Magnetic Materials, Nov. 13-16, 1973, Boston. A Spherical Tensor Operator Description of the Exchange Splittings of Gd^{3+} in $GdCl_3$, R.S. Meltzer and R.L. Cone.

1974 Spring Meeting of APS, April 22-25, 1974, Washington, D.C.

Conference on Critical Phenomena in Multicomponent Systems, April 15-17, 1974, Athens, GA.

VIII International Quantum Electronics Conference, June 10-13, 1974, San Francisco.

2nd International Conference on Spectral Lines, Aug. 26-30, 1974, Eugene, OR. Observation of $13cm^{-1}$ Homogeneous Broadening in the Emission Spectrum of $Tb(OH)_3$, R.L. Cone and R.S. Meltzer.

20th Annual Conference on Magnetism and Magnetic Materials, December 3-6, 1974, San Francisco, CA. Observation of Virtual Phonon Exchange in a Magnon-Like Exciton of $Tb(OH)_3$, R.L. Cone and R.S. Meltzer. A Systematic Study of the Orbitally Dependent Rare Earth Gd^{3+} Exchange Parameters in $GdCl_3$, R.S. Meltzer and R.L. Cone.

1975 March Meeting of APS, March 21-April 3, 1975, Denver, CO. A Systematic Study of the Orbitally-Dependent Rare Earth-Gd^{3+} Exchange Parameters in $GdCl_3$, R.L. Cone, R.S. Meltzer, and D.K. Braswell. Excitation Transfer Mechanisms from Line Shapes of Exciton Fluorescence in $Tb(OH)_3$, R.S. Meltzer and R.L. Cone.

1975 Annual Meeting of the Optical Society of America, Oct. 21-24, 1975, Boston.

1976 March Meeting of APS, March 29 - April 1, 1976, Atlanta.

MSU Physics Colloquium, February 25, 1977. Laser Diagnostic Techniques Applicable to Magneto-Hydro Dynamics and Combustion Analysis, R.L. Cone.

CONFERENCE PAPERS, SEMINARS, AND COLLOQUIA (continued)

1977 March Meeting of APS, March 21-24, 1977, San Diego. Optical Energy Transfer Via the Electronic Exchange Interaction in Eu^{2+} and Gd^{3+} Compounds, R.L. Cone.

Third International Conference on Laser Spectroscopy, Jackson, Wyoming, July 4-8, 1977.

CHAIRMAN OF SESSION, 23rd Annual Conference on Magnetism and Magnetic Materials, Nov. 8-11, 1977, St. Paul, MN. Session on Raman and Optical Properties.

Annual Sigma Xi meeting, Montana State University, April, 1977, invited talk. Application of Lasers in Science and Technology, R.L. Cone.

Stanford University, MHD Workshop, April 1977. Diagnostics for Combustion MHD, R.L. Cone, R.D. Nelson, and D.A. Ender.

MSU Chemistry Colloquium, 1978. Coherent Raman Spectroscopy, R.L. Cone.

Conference on Dynamical Processes in the Excited States of Ions and Molecules in Solids, U. of Ga., Athens, June 2-3, 1978. High Resolution Measurement of Exciton Scattering by Stimulated Band to Band Fluorescence, R.L. Cone.

CHAIRMAN OF SESSION: Session on Electron-Phonon and Other Dynamical Processes.

1979 March Meeting of APS, Chicago, March 19-23, 1979. High Resolution Measurement of Exciton Scattering by Stimulated Band to Band Fluorescence, R.L. Cone.

2nd Conferences on Dynamical Processes in Excited States of Ions and Molecules in Solids, Madison, Wisconsin, June 18-20, 1979.

March APS Meeting, New York, 1980. Systematics of Phonon Raman Spectra in the Rare Earth Hydroxides, R.L. Cone, M.S. Otteson, D.A. Ender, and P.T. Schnackenberg.

INVITED TALK, Bell Laboratories, Murray Hill, April 4, 1980. Dynamical Measurements of Coherence and Relaxation Effects Involving Excitons in Magnetic Insulators, R.L. Cone.

INVITED TALK, Yale University, Solid State and Applied Quantum Physics Seminar, May 2, 1980. Dynamical Effects Involving Excitons in Magnetic Insulators, R.L. Cone.

INVITED TALK, Exxon Corporate Research Center, July 1, 1980. Optical Studies of Energy Transfer and Exciton Dynamics in Concentrated Rare Earth Insulators, R.L. Cone.

Picosecond Phenomena, N. Falmouth, Massachusetts, June 18-20, 1980.

International Quantum Electronics Conference, Boston, June 23-26, 1980.

MSU Physics Colloquium, January 9, 1981. Nonlinear Laser Spectroscopy: Four Wave Mixing in Solids, R.L. Cone.

CONFERENCE PAPERS, SEMINARS, AND COLLOQUIA (continued)

March APS Meeting, Phoenix, 1981. Doubly-Resonant, Two-Photon- Absorption-Induced Four-Wave Mixing in Solids: $Tb(OH)_3$, R.L. Cone, J.M. Friedman, R.A. Stepnoski, D.A. Ender, M.S. Otteson, and P.L. Fisher.
Optical Dephasing in Solid Via Two-Photon-Absorption Four-Wave Mixing with Intermediate State Resonances, D.A. Ender, M.S. Otteson, R.L. Cone, and J.M. Friedman.

INVITED TALK, Clarendon Laboratory, University of Oxford. Oxford, U.K., July 16, 1981, Coherent Laser Spectroscopy in Rare Earth Insulators, R.L. Cone.

1981 International Conference on Luminescence, Berlin, July 20-24, 1981.

3rd International Conference on Dynamical Processes in the Excited States of Ions and Molecules in Solids, Regensburg, FRG, July 29-31, 1981. Doubly-Resonant, Two-Photon-Absorption-Induced Four-Wave Mixing in Solids: $Tb(OH)_3$, R.L. Cone, D.A. Ender, M.S. Otteson, J.M. Friedman, and R.A. Stepnoski.

Conference on Laser Techniques for Extreme Ultraviolet Spectroscopy, Boulder, Colorado, March 8-10, 1982, Multiresonant Two-Photon- Absorption-Induced Four-Wave Mixing in Crystalline Rare Earth Insulators,
R.L. Cone, D.A. Ender, M.S. Otteson, P.L. Fisher, J. M. Friedman, and H.J. Guggenheim.

1982 March Meeting of APS, March 9-12, 1982, Dallas, Texas, Saturation of Excitation Density in Fluorescence Excitation Spectra of $Tb(OH)_3$ and $LiTbF_4$, D.A. Ender, M.S. Otteson, R.L. Cone, J.M. Friedman, and H.J. Guggenheim.
Narrowed Intermediate State Resonance in Multiresonant, Two-Photon-Absorption-Induced Four-Wave Mixing in $Tb(OH)_3$ and $LiTbF_4$, D.A. Ender, M.S. Otteson, R.L. Cone, J.M. Friedman, and H.J. Guggenheim.

Third Topical Meeting on Picosecond Phenomena, Garmisch-Partenkirchen, FRG, June 16-18, 1982.

XII International Quantum Electronics Conference, Munich, FRG, June 22-25, 1982, Multiresonant Two-Photon-Absorption-Induced Four-Wave Mixing in Crystalline Rare Earth Insulators, R.L. Cone, D.A. Ender, M.S. Otteson, Paula L.Fisher, J.M Friedman, and H. J. Guggenheim.

Fourth International Conference on Dynamical Processes in the Excited States of Solids, Stanford, July 11-14, 1983. Saturation of Excitation Density and Novel Exciton-Exciton-Annihilation Dynamics in $LiTbF_4$ and $Tb(OH)_3$, D.A. Ender, M.S. Otteson, P. Darejeh, R.L. Cone, J.M. Friedman, and H.J. Guggenheim,
Optical Coherent Transients and Hole Burning of the $^7F_0$-$^5D_0$ Transition in $Eu(OH)_3$, M.S. Otteson, R.L. Cone, R.M. Macfarlane, and R.M. Shelby,
Photon Echoes in Tb^{3+}:$LiYF_4$ and Pr^{3+}:$LiYF_4$, P. Darejeh, M.S. Otteson, R.L. Cone, and H.J. Guggenheim.

CONFERENCE PAPERS, SEMINARS, AND COLLOQUIA (continued)

1984 March Meeting of APS, March 26-30, 1984, Detroit, Michigan, Quantitative Analysis of Narrowed Intermediate Resonances in Multiresonant Four Wave Mixing in $LiTbF_4$, M. S. Otteson, D. A. Ender, R. L. Cone, and J. M. Friedman, Nuclear Quadrupole Optical Hole Burning Studies of Defect Sites in Stoichiometric $EuVO_4$, R.L. Cone, R.T. Harley, and M.J.M. Leask.

INVITED PANELIST, 1984 International Conference on Luminescence, August 13-17, 1984, Madison, Wisconsin, Workshop on Frontiers in Crystal Field Theory.

INVITED TALK, Argonne National Laboratory, Chemical Physics Seminar, August 20, 1984, Multi-Resonant Four-Wave Mixing in Rare Earth Compounds, R.L. Cone.

MSU Laser Interaction Seminar, January 15, 1985, Laser Hole Burning Spectroscopy of Eu^{3+} Compounds, R.L.Cone.

Fifth International Conference on Dynamical Processes in the Excited States of Solids, Universite Lyon, July 1-4, 1985. Exciton Dynamics Following Two Photon Absorption in $GdCl_3$, R. Mahiou, B. Jacquier, and R.L. Cone.

INVITED TALK, le Laboratoire de Physico-Chemie des Materiaux Luminescents, Universite Lyon, July 8, 1985, Multiresonant Four-Wave Mixing in Terbium Compounds, R.L. Cone.

INVITED TALK, le Laboratoire de Physico-Chemie des Materiaux Luminescents, Universite Lyon, July 10, 1985, The Correlation of Structural and Optical Properties of Rare Earth Activated Materials via Holeburning Spectroscopy, R.L. Cone.

INVITED TALK, Physics Department Colloquium, Oklahoma State University, Stillwater, October 30, 1985, The Correlation of Structural and Optical Properties of Rare Earth Activated Materials via Holeburning Spectroscopy, R.L. Cone.

INVITED TALK, Physics Department Colloquium, University of Arkansas, Fayetteville, November 1, 1985, The Correlation of Structural and Optical Properties of Rare Earth Activated Materials via Holeburning Spectroscopy, R.L. Cone.

INVITED TALK, le Laboratoire de Spectrometrie Physique, Universite Scientifique at Medicale de Grenoble, February 25, 1986, Interaction Mechanisms Between Rare Earth Ions in Solids, R.L. Cone.

INVITED TALK, le Laboratoire de Physico-Chimie des Materiaux Luminescence, Universite Lyon, March 5, 1986, Electronic Exchange Interaction Effects in Rare Earth Compounds, R.L. Cone.

INVITED CONFERENCE TALK, Seventeenth Rare Earth Research Conference, McMaster University, Hamilton, Ontario, June 8-12, 1986, "The Correlation of Structural and Optical Properties of Rare Earth Activated Materials via Holeburning Spectroscopy, R.L. Cone.

INVITED TALK, Lawrence Livermore National Laboratory, June 23, 1986, The Correlation of Structural and Optical Properties of Rare Earth Activated Materials, R.L. Cone.

CONFERENCE PAPERS, SEMINARS, AND COLLOQUIA (continued)

Sixth International Conference on Dynamical Processes in Excited States of Solids, Tsukuba, Japan, August 11-14, 1987, Photon Echo Relaxation and Hole Burning in Tb^{3+}:$LiYF_4$ and $LiTbF_4$, G.K. Liu, M.F. Joubert, R.L. Cone, and B. Jacquier, Direct Two-Photon Absorption of Gd(OH)3 and $GdCl_3$ in an Applied Magnetic Field, B. Jacquier, Y. Salem, C. Linares, J.C. Gacon, R. Mahiou, and R.L. Cone.

1987 International Conference on Luminescence, Beijing, China, August 17-21. 1987, Direct Two-Photon Excitation in Some Tb^{3+} Materials, B. Jacquier, J.C. Gacon, J.F. Marcerou, M.F.Joubert, and R.L. Cone,
Photon Echo Relaxation and Hole Burning in Tb^{3+}:$LiYF_4$ and $LiTbF_4$, G.K. Liu, M.F. Joubert, R.L. Cone, and B. Jacquier.

Third International Laser Science Conference, Atlantic City, NJ, November 1-5, 1987, Resonant Enhancement of Direct Two-Photon Absorption in Tb^{3+}:$LiYF_4$, J. Huang, G.K. Liu, and R.L. Cone
Delocalized and Localized States in $LiTbF_4$ Probed via Photon Echoes, G.K. Liu, M.F. Joubert, and R.L. Cone.

INVITED TALK, Yale University, Section of Applied Physics, November 9, 1987, Delocalized and Localized States in $LiTbF_4$ Probed via Photon Echoes, R.L.Cone.

1988 March Meeting of APS, New Orleans, March 21-25, 1988, Energy Transfer and Delocalization in Optically Excited States of $LiTbF_4$ and $Tb(OH)_3$, G.K. Liu and R.L. Cone, Resonant Enhancement of Direct Two-Photon Absorption in Tb^{3+}: $LiYF_4$, J. Huang, G.K. Liu, R.L. Cone,
Nuclear Quadrupole Optical Holeburning in Stoichiometric $EuAsO_4$, M.G. Robinson, M.J.M. Leask, and R.L. Cone,
Power-Dependent Photon Echo Decay due to "Instantaneous Diffusion" in Tb^{3+}:$LiYF_4$, R.L. Cone and G.K. Liu.

INVITED TALK, Nonlinear Optical Spectroscopy of Rare Earth Ions in Solids using Photon Echoes and Spectral Hole Burning, 3M Technical Forum--Physics Chapter and Photochemistry Chapter, St. Paul, MN, March 13, 1989.

1989 March Meeting of APS, St. Louis, March 20-24, 1989, Transferred Hyperfine Interactions in Tb^{3+}:LiY_4 via Photon Echo Modulation, G.K. Liu and R.L. Cone

INVITED CONFERENCE TALK, Energy Transfer and Instantaneous Spectral Diffusion Processes in Tb^{3+} Compounds as Probed in Photon Echo Experiments, Seventh International Conference on Dynamical Processes in Excited States of Solids (DPC'89), R.L. Cone

INVITED TALK, Energy Transfer and Instantaneous Spectral Diffusion Processes in Tb^{3+} Compounds as Probed in Photon Echo Experiments, at Physics Department, University of Southampton, UK, October 16, 1989.

INVITED TALK, Resonant Enhancement of Direct Two-Photon Absorption in Tb^{3+}:LiY_4--Two Transition Mechanisms, at Laboratoire de Physico-Chemie des Materiaux Luminescents, Universite Claude Bernard, Lyon, France, October 20, 1989.

CONFERENCE PAPERS, SEMINARS, AND COLLOQUIA (continued)

INVITED TALK, Energy Transfer and Instantaneous Spectral Diffusion Processes in Tb^{3+} Compounds as Probed in Photon Echo Experiments, at Laboratoire de Physico-Chemie des Materiaux Luminescents, Universite Claude Bernard, Lyon, France, October 23, 1989.

INVITED TALK, Transfert d'energie et diffusion spectrale dans des composes a base de Tb^{3+} mesures par echo de photon, at Laboratoire de Spectrometrie Physique, Universite Joseph Fourier Grenoble I, Grenoble, France, October 26, 1989.

INVITED TALK, The Impact of Technology on Photography, at PHOTOGRAPHY: YESTERDAY, TODAY & TOMORROW, a two-day symposium at the Museum of the Rockies, funded by the Montana Committee for the Humanities and MONTS, December 10, 1989.

RESEARCH CONTRACTS OR GRANTS DIRECTED:

Agency	Title	Dates	Amounts
NSF	"Optical Properties of Some Second and Third Row Transition Metal Magnetic Insulators"	1974-1975	$23,900
Research Corporation	Mechanisms of Energy Transfer in Solid State Laser Materials	1974-1975	$15,542
NSF	Optical Investigation of Exciton Dispersion in Magnetic Insulators	1975-1976	$ 7,000
NSF	Coherent Laser Studies of Dynamic Cooperative Phenomena in Solids	1980-1983	$52,100 $60,500 $53,000 $68,000 $233,600
NATO	Exciton-Exciton Annihilation and Saturation Effects in Magnetic Rare Earth Insulators	1984-1986	$ 5,000
MSU	Optically-Detected Nuclear Magnetic Resonance and Nuclear Quadrupole Resonance	1985	$ 4,000
IBM	Isotopically Pure $Eu(OH)_3$ Crystals	1985	$ 3,000
NATO	Renewal	1986-1988	$ 5,000
NSF/MONTS	Exciton Dynamics in Stoichiometric and Dilute Rare Earth Compounds via Photon Echoes	1987-1988 1988-1989	$ 13,000 $ 14,400
Research Corporation	Correlation of Structural and Optical Properties of Rare Earth Activated Materials via RF-Optical Double Resonance and Hole Burning	1987-88	$ 20,250
Ramtron Corporation	Photoluminescence Studies and Laser Spectroscopy of Ferroelectric Semiconductors	1989	$ 25,111

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652-1050

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652-1122

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252-9381

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2110 Overland Ave., Suite 104a
Billings, MT 59102
652-5401

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Rimrock Mall
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656-5814

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Billings, MT 59101
245-8458

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Rimrock Mall
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652-6755

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Billings, MT 59102
656-0137

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Billings, MT 59102
256-0627

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1430 Central Ave.
Billings, MT 59102
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1201 Grand Avenue
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2520 17th Street West
Billings, MT 59102
245-5704

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141 Florine Lane
Billings, MT 59101
259-7539

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259-5896

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January 29, 1991

Honorable Stan Stephans
State of Montana
Capital Building
Helena, MT 59601

Dear Governor Stephans,

I am pleased to learn that Montana has chosen to submit a proposal to participate in our nation's Laser Interferometric Gravitational-Wave Observatory effort. The LIGO experiment certainly represents the leading edge of experimental physics and may establish a cornerstone of knowledge for future generations of scientists.

I would like to add my enthusiastic support to Montana's proposal. I believe that our university resources and growing infrastructure of high technology companies would provide a valuable resource to the project. Additionally, the LIGO project would have an accelerating effect on Montana's economic growth and diversification.

If there is anything I can personally do to assist the State's proposal effort do not hesitate to call me.

Sincerely,

Lawrence A. Johnson
President and CEO

JAN 1991
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LATTICE

January 25, 1991

Ms. Dixie F. Swenson
Executive Director
Gallatin Development Corp
321 East Main, Suite 413
Bozeman, MT 59715

Dear Dixie:

I appreciate the material you sent me on the LIGO project. I believe the project has merit, and could be nicely supported by industries in the Bozeman - Billings areas.

As you are aware, Lattice Materials Corporation is a manufacturer of silicon crystals used in the I.R. laser and imaging markets. Our mission is to be the leading supplier in the silicon I.R. industry, with the possibility of expanding into additional crystal products as time goes by.

Although our area of expertise is narrow, if any of the optical components mentioned are made of silicon, we could be a direct supplier to the LIGO project. In addition, Lattice would also be a resource for various optical fabrication requirements.

Dixie, when and if appropriate, I would be happy to conduct a tour of our facility for personnel involved with this project.

Sincerely,

John L. Tengelsen
President

Lattice Materials Corp.
516 E. Tamarack
Bozeman, MT 59715
406 586-2122
FAX. 406 587-9055

SCIENTIFIC MATERIALS CORP.

MANUFACTURERS OF MATERIALS FOR OPTO-ELECTRONICS

January 24, 1991

The Honorable Stan Stevens
State of Montana
Capital Building
Helena, MT 59601

Dear Governor Stevens:

This letter is in response to your request for local support of your efforts to obtain the LIGO project for the State of Montana. I fully lend my support to this effort, recognizing this project as ideal for the State of Montana. I feel the infrastructure in place in Bozeman can support the needs of this project. The community has leaders in material development, laser optics, laser devices and laser testing. The industrial support, coupled with the facilities of Montana State University, provides this necessary infrastructure.

It is my opinion that Montana has much to offer a project such a LIGO. The work force is highly motivated, with an excellent educational background. The project can be isolated with a minimum impact to the local area. The commute time from the project location to desirable living areas is most reasonable, nominally being one hour. Existing transportation more than adequately supports the services. In the two year period of our existence in Bozeman, we have had one delayed shipment into our facility.

If I can be of further service in your efforts to obtain this project for Montana, please have your staff contact me at their convenience.

Yours truly,

SCIENTIFIC MATERIALS CORPORATION

Ralph L. Hutcheson
President

310 Icepond Road, Bozeman, MT 59715 • (406) 585-3772
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